NATIONAL OCCUPATIONAL RESEARCH AGENDA

SECOND DECADE IN REVIEW

NIOSH Sector and Cross-Sector Program Supplement | 2006–2016

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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NATIONAL OCCUPATIONAL RESEARCH AGENDA: NIOSH Sector and Cross-Sector Program Supplement | 2006–2016

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DEPARTMENT OF HEALTH AND HUMAN SERVICES
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RESPIRATOR VIDEO

NIOSH work provided the basis for parts of a respirator-safety video from the Occupational Safety and Health Administration to show workers how to properly put on and take off a respirator.

DIGITAL LUNG X-RAYS

NIOSH research on using digital lung X-rays to classify occupational dust diseases significantly contributed to new standards and rules from the International Labour Organization and the U.S. Department of Labor's Office of Workers' Compensation Programs.

RESPIRATOR STANDARDS

NIOSH work to measure nanoparticles penetrating respirators informs researchers and organizations developing new or revised standards in this area.

BERYLLIUM PROTECTIONS

NIOSH studies of beryllium's health effects led to Materion and the United Steelworkers' union adopting and recommending to the Occupational Safety and Health Administration a consensus standard for a lowered permissible exposure limit for the metal.

RESPIRATOR SOFTWARE

NIOSH software helps universities, manufacturers, and occupational-safety workers develop training programs to identify when a respirator cartridge stops working.

EFFECTS OF FLAVORINGS

NIOSH research and recognition that occupational exposure to the butter flavorings diacetyl and 2,3′-pentanedione are associated with significant risk for a serious, irreversible lung disease increased public awareness and efforts to improve worker protection. For example, the Occupational Safety and Health Administration started a special emphasis program on diacetyl in 2009, and then proposed rulemaking, and the state of California adopted standards in 2010.

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BETTER STANDARDS

NIOSH work contributed to several groups issuing improved standards for respirators and respirator equipment. These groups include the Mine Safety and Health Administration, the National Fire Protection Association, the International Organization for Standardization, the American National Standards Institute, and the American Society for Testing and Materials.

PPE CALCULATOR

A NIOSH calculator that helps analyze personal protective equipment's protection against chemicals contributed to a new standard from the American Society for Testing and Materials.

BIOMARKER RESEARCH

NIOSH research on dust-exposure biomarkers led the U.S. Department of Defense to develop ways to assess risk and prevent exposure in Iraq.

ABBREVIATIONS

AAMI	Association for the Advancement of Medical Instrumentation
AATCC	American Association of Textile Chemists and Colorists
AFF	Agriculture, Forestry, and Fishing
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
AUR	Authoritative Recommendations
CDC	Centers for Disease Control and Prevention
CON	Construction
CRC	Cancer, Reproductive, and Cardiovascular Diseases
DLO	Divisions, Laboratories, and Offices
ECN	Economics
ENG	Engineering Controls
EPA	Environmental Protection Agency
EPR	Emergency Preparedness and Response
EXA	Exposure Assessment
FY	Fiscal Year
GLC	Global Collaborations
HHE	Health Hazard Evaluation
HHS	U.S. Department of Health and Human Services
HLP	Hearing Loss Prevention
HSA	Healthcare and Social Assistance
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
MIN	Mining
MIO	Oil and Gas Extraction
MNF	Manufacturing
MOU	Memorandum of Understanding
MSD	Musculoskeletal Disorders
MSHA	Department of Labor Mine Safety and Health Administration
NAICS	North American Industry Classification System
NAN	Nanotechnology
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NORA	National Occupational Research Agenda
OECD	Organization for Economic Cooperation and Development
OEP	Office of Extramural Programs

SAFER NANOTECHNOLOGY

NIOSH work led to the Occupational Safety and Health Administration and the Environmental Protection Agency developing recommendations for working with multi-walled carbon nanotubes.

WORK-RELATED ASTHMA

NIOSH research led to the American Thoracic Society starting a workgroup and publishing an official statement on work-related asthma.

OSHA	Occupational Safety and Health Administration
PPT	Personal Protective Technology
RDR	Respiratory Diseases
SBA	Small Business Assistance and Outreach
SPS	Public Safety
SUR	Surveillance
SVC	Services
TRI	Traumatic Injury
TWH	Total Worker Health®
TWU	Transportation, Warehousing and Utilities
UL	Underwriters Laboratory
USCG	Department of Homeland Security US Coast Guard
WHO	World Health Organization
WRT	Wholesale and Retail Trade
WSD	Work Organization and Stress Related Disorders

DEFINITIONS

All Sectors: Classification for NIOSH research that applies to most, if not all sectors. NIOSH catalogs and tracks most of its research (including outputs and outcomes) by the most closely associated one or two NORA sectors. However, some research inherently relates to most or all industries, such as some occupational health disparities research, so NIOSH's sector classification for that research or output is "All Sectors."

Intermediate Outcome: Actions by stakeholders in response to NIOSH products or efforts (such as making policy changes; producing standards or regulations; adopting NIOSH-developed technologies; using publications, technologies, methods, or recommendations by workers, industry, and occupational safety and health professionals in the field; and citing NIOSH research by industry and academic scientists.)

End Outcome: Improvements in safety or health in the workplace that can be attributed to NIOSH efforts—specifically, reducing work-related injuries, illnesses, or deaths or reducing hazardous exposures in the workplace.

Impact: A collective term used to refer to both intermediate and end outcomes. Impacts can be qualitative (a success story) or quantitative (an increase or decrease in a numerical indicator). They can occur at any scale, ranging from a single workplace to the local, state, or national level.

NIOSH: Federal health institute in the Department of Health and Human Services, Centers for Disease Control and Prevention, responsible for generating new knowledge in the field of occupational safety and health and transferring it into practice globally. To accomplish this mission, NIOSH does scientific work that includes research, field investigations, surveillance, and authoritative recommendations.

NIOSH Cross-Sector Program: Internal program established and managed by NIOSH to coordinate its research and partnership efforts associated with a topic area that has application across many or most industrial sectors. Each cross-sector program sets priorities for NIOSH research and develops relationships with academic, government, and private stakeholders interested in their topic area. Cross-sector programs are organized into health and non-health outcome areas to support the sectors in accomplishing their goals for the nation and coordinate priorities that affect multiple sectors. The health outcome cross-sectors represent the major occupational safety and health issues faced by workers, and non-health outcome cross-sectors represent research methods, approaches, and core activities such as surveillance, hazard exposure, interventions, information dissemination, and statutory programs.

NIOSH Sector Program: Internal program established by NIOSH to coordinate its research and partnership efforts associated with each of 10 defined NORA sectors. Each sector program sets priorities for NIOSH research and develops partnerships with academic, industry, labor, and government stakeholders related to those industries.

NEW EPA PROTECTIONS

NIOSH recommended exposure levels for carbon nanotubes and titanium dioxide provided the U.S. Environmental Protection Agency with information to develop regulations to protect workers who handle engineered nanomaterials.

PPE DECONTAMINATION

NIOSH study results are included in an American Industrial Hygiene Association guideline for decontaminating personal protective clothing and equipment after use.

REDUCING LEAD EXPOSURE

The NIOSH blood-lead surveillance program, ABLES, identified unsafe conditions and industries, and the Occupational Safety and Health Administration used this information to update its "National Emphasis Program–Lead" to reduce work-related lead exposure.

NIOSHTIC-2: A searchable bibliographic database of occupational safety and health publications, documents, grant reports, and other communication products supported in whole or in part by NIOSH.

NORA: Partnership program to stimulate innovative research and improved workplace practices. Established by NIOSH in 1996, NORA has provided a research framework in occupational safety and health for NIOSH and the nation. NORA participation is broad, including stakeholders from universities, large and small businesses, professional societies, government agencies, and worker organizations. These diverse parties collaborate to identify the most critical issues in workplace safety and health.

NORA Sector: Industry group based on business sector definition in the North American Industry Classification System (NAICS), organized into NORA Sectors based on similarities they face in workplace safety and health issues (see The Sector and Cross-Sector Approach).

NORA Sector Council: Partnership volunteers that represent a broad range of stakeholders in one of the 10 NORA sectors. Councils meet to set goals for the nation, develop strategies, encourage partnerships, and promote improved workplace practices in their sector. NIOSH facilitates their work.

SECTOR AND CROSS-SECTOR PROGRAM SUPPLEMENT

This supplement supports the *NORA Second Decade in Review (2006–2016)* report and highlights the many contributions the NIOSH sector and cross-sector programs made during the National Occupational Research Agenda's second decade. The supplement has two main sections: Sector Program Review and Cross-Sector Program Review. The Cross-Sector Program Review is further organized into the Health Outcome Cross-Sector Programs and the Non-Health Outcome Cross-Sector Programs. NIOSH program leadership prepared these highlights. The *NORA Second Decade in Review (2006–2016)* report lists the many people who made these accomplishments possible.

STRESSES FROM PPE

NIOSH research contributed to a 2008 standard from the American Society for Testing and Materials for determining physiological stresses from wearing personal protective clothing ensembles.

GATHERING DEATH DATA

NIOSH and the states coordinate procedures to help compile national work-related data for death certificates.

SECTOR PROGRAM REVIEW

PPE NANO RESISTANCE

NIOSH methods to measure protective clothing's resistance to nanoparticles contributed to new guidance documents, requirements, and test methods from other government agencies, organizations, and manufacturers.

RADIATION RESEARCH

NIOSH research on radiation exposure at work led to the Occupational Safety and Health Administration's request for the risk-assessment information.

NORA organized its second decade around 10 sector programs representing major areas of the U.S. economy. This organization gave NIOSH and the nation a way to effectively shape a research agenda and move research into practice. The 10 sector programs created councils with representation from key stakeholders and NIOSH. Together, the NIOSH sector programs and the NORA sector councils developed a research agenda for the nation. To further assess the results of NORA's second decade, NIOSH conducted an in-depth review of the activities, effectiveness, outcomes, and impact of each of the 10 sectors. This report summarizes the review.

AGRICULTURE, FORESTRY, AND FISHING


Photo by Thinkstock

The Agriculture, Forestry and Fishing (AFF) sector comprises operations that primarily work to grow crops, raise animals, harvest timber, and harvest fish and other animals. Harvesting takes place on farms, ranches, or natural habitats. Workers in this sector face risks that include animal handling, falls, infectious diseases, overexertion, tractor rollovers, chemicals, and machinery.

The NORA Agriculture, Forestry, and Fishing (AFF) Sector Council first met in February 2007 to discuss health and safety issues in this sector and brainstorm possible research that may lead to decreasing illness and injuries to AFF workers. The council consisted of members from industry, academia, professional associations, health and safety professionals, and government. The nine members of the NIOSH intramural AFF steering committee also participated in the sector council. During this second decade of NORA, the council has consisted of about 30 full members and 90 corresponding members. Full members participated in annual face-to-face meetings and as leaders in working groups. Corresponding members participated as working-group members and received information from annual council meetings via e-mail and

Pesticide Poisoning Monitoring Program Protects Farmworkers

Physicians annually diagnose 10,000 to 20,000 pesticide poisonings among the estimated 2 million agricultural workers in the United States. NIOSH established the Sentinel Event Notification System for Occupational Risks—Pesticides Program (SENSOR-Pesticides) in 1987 to serve as an early warning system for harmful effects associated with occupational pesticide exposure. Eleven states monitor pesticide-related illness and injury through the program.

In 2005, three migrant farmworkers living in the same region of Florida gave birth to infants with birth defects within 8 weeks of each other. The SENSOR-Pesticides Program helped states to collaborate, revealing that the three mothers worked for the same tomato grower during the maximum sensitivity periods of their pregnancies. Two worked at the grower's Florida operations, and one worked in North Carolina. After further investigation, North Carolina created a taskforce whose findings motivated the state legislature to pass anti-retaliation and recordkeeping laws, training mandates to protect the health of agricultural workers, and funding for improved surveillance. The Florida state legislature funded 10 new pesticide inspectors.

SENSOR data contributed to the 2015 Environmental Protection Agency's (EPA) new proposed rule on restricted use pesticide applicator certifications. EPA used SENSOR-Pesticides Program data that the revised rule benefits outweigh the costs.

Details: NIOSH Pesticide Poisoning Monitoring Program Protects Farmworkers

ROLLOVER RESEARCH

NIOSH research with other organizations provided science-based evidence for the American Society of Agricultural and Biological Engineers (ASABE) to develop a consensus document (Performance Standard X-599) to protect farmworkers from serious injury or death in tractor rollovers. ASABE developed the document in 2010 and reaffirmed it in 2014.

BALER HAZARDS

NIOSH information on baler hazards informed the American National Standards Institute when revising its standard on baling equipment safety.

electronic mailing lists. The council is divided into seven working groups that represent each of the strategic goals (forestry safety and health were combined, and fishing safety and health were also combined). Working groups met multiple times each year to formulate, promote, and evaluate the strategic plan.

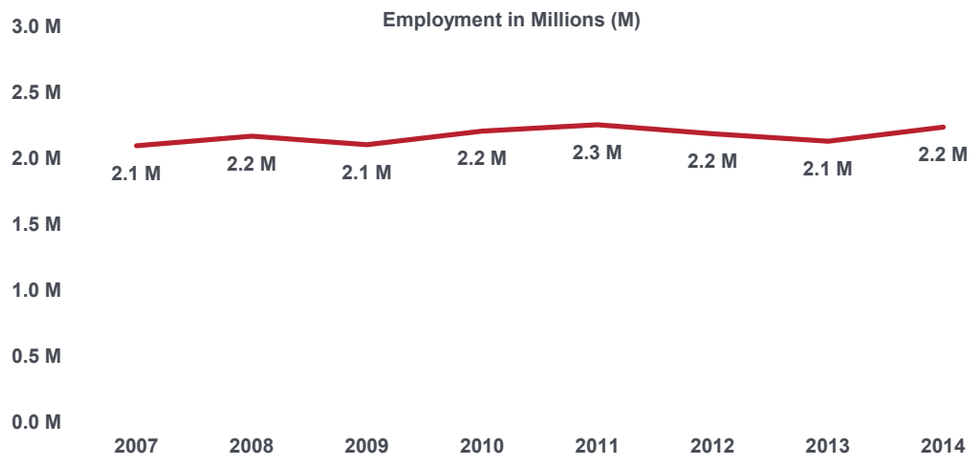
The first phase of the NORA AFF Sector Council assessed issues and developed goals for safety and health research in this sector. The council identified nine strategic goals, and council members assigned working groups to each strategic goal. Working groups met independently to formulate intermediate goals and short-term action steps to correspond with each strategic goal. The council also saw the need for two more resources. The council assembled a Dictionary of Terms (Appendix 2 to the Strategic Plan) specific to safety and health research for this sector, and the council included information on the Forestry Workforce, Statistics, and Organization in Appendix 1 in the final strategic plan. A draft version of the Strategic Plan was published for public comment in March 2008. After receiving and responding to comments, the final version was published on the NORA website in December 2008, including both appendices. After publishing the strategic plan and goals, the council entered the second phase (2008–2014), which focused on implementing the plan, with council members promoting the plan to researchers and industry. Efforts were made to identify and contact researchers and stakeholders to let them know of the NORA goals and how they could help address relevant goals. The third phase (2015–2016) is underway and involves evaluating the use of the strategic plan and determining goals accomplished.

The AFF council found it helpful to have input from the many corresponding members in each phase of the decade's NORA process. The corresponding members gave a broad base of input for the strategic plan and also helped to spread the word about NORA. During the second phase, many council members gave presentations at conferences addressing researchers and stakeholders about the Strategic Plan and goals. By 2010, the AFF council had identified 11 activity or output goals that had been met.

Trends in Agriculture, Forestry, and Fishing Employment, Fatalities, Injuries, and Illnesses

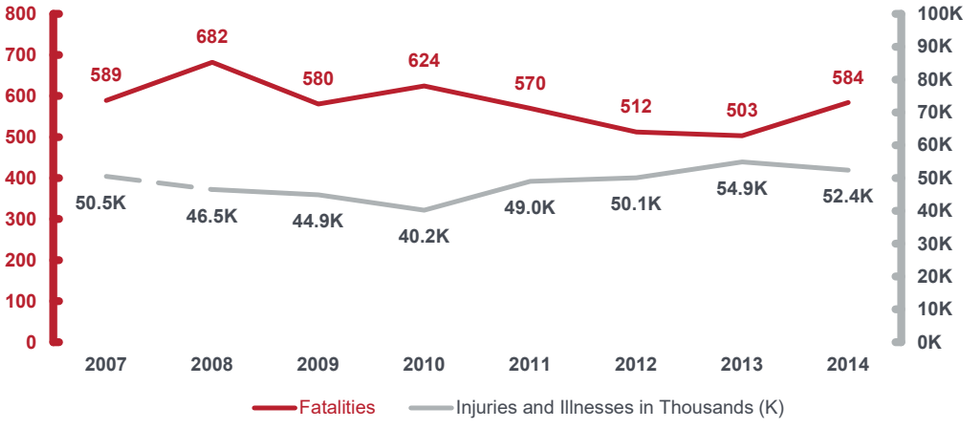
Background rates for employment in the sector, fatalities, and nonfatal injuries give context for the review of the Agriculture, Forestry, and Fishing (AFF) activities, effectiveness, and impact during the decade. From 2007 through 2014, employment in the AFF sector remained fairly stable (Figure 1). Employment data were collected from the Current Population Survey and includes private industry and government (federal, state, and local) and the self-employed. Volunteers are not included in employment counts. The number of fatalities generally declined during the decade, with peaks in 2008, 2010, and 2014 (Figure 2). The NORA decade began in 2007 with nonfatal injuries and illnesses (Figure 2) at 51,000. They hit a low of 40,000 injuries and illnesses in 2010 and then rose to a high of nearly 55,000 in 2013. Fatality and injury data were collected from the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Injuries and Illnesses (SOII). The latter does not include self-employed, and only private industry data were available before 2008.

Figure 1. Employment trends in agriculture, forestry, and fishing (2007 through 2014)



Employment data: Bureau of Labor Statistics, Current Population Survey (CPS).

Figure 2. Fatality, injury or illness trends in agriculture, forestry, and fishing (2007 through 2014)



Fatality data: Bureau of Labor Statistics, Census of Fatal Occupational Injuries (CFOI). Injury or illness data: Bureau of Labor Statistics, Survey of Occupational Injuries and Illnesses (SOII).

Activities and Output

Figure 3 shows how many research projects (intramural and extramural) contributed effort to the AFF Sector Program during the decade. Project counts reflect the percentage of total effort directly attributable to the AFF Sector Program. Example: If one project is attributed as 50% effort in AFF, then it is counted as 0.50 of a project.

FOREST MACHINERY

NIOSH research led the International Organization for Standardization to develop an international standard to protect forest-machinery operators from thrown objects. The standard calls for improving the machinery's window glazing.

CAB CONTAMINATION

NIOSH work on the leakage of contaminants into enclosed tractor cabs contributed to the American Society of Agricultural Engineers revising a standard to remove all statements regarding the use of enclosed tractor cabs in lieu of more protective respirators.

PESTICIDE STANDARD

Results from the NIOSH SENSOR-Pesticides program contributed to the U.S. Environmental Protection Agency's updating its pesticide Worker Protection Standard.

SAMPLING WOOD DUST

NIOSH recommendations for sampling wood dust led to the American Forest & Paper Association accepting this methodology.

Figure 3. Number of agriculture, forestry, and fishing research projects (FY2007 through FY2015)

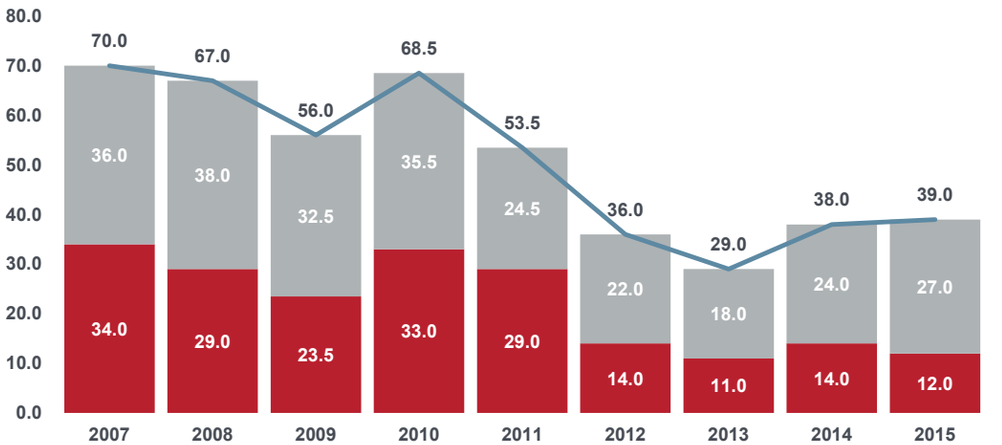
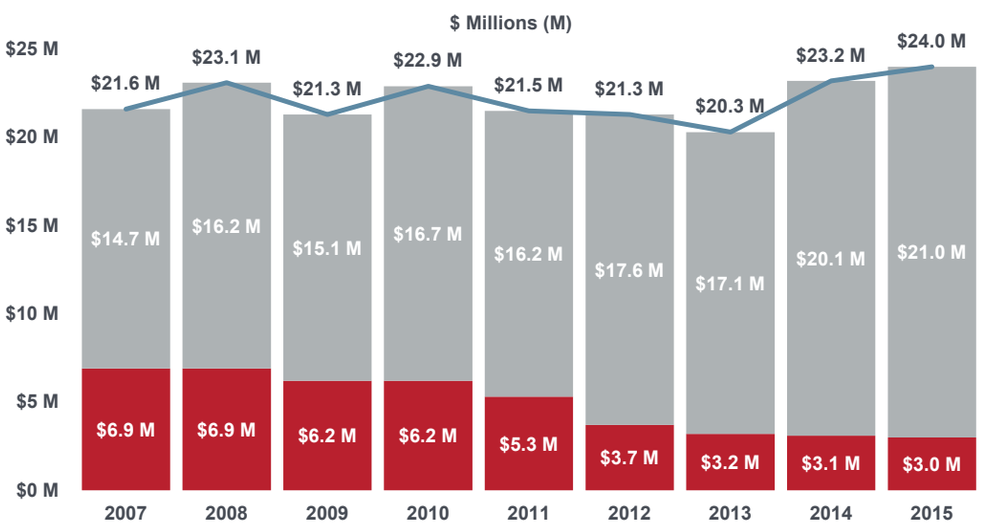


Figure 4 shows the funds invested in intramural and extramural research projects from 2007 through 2015. Investment totals reflect the percentage of total effort directly attributable to AFF Sector Program research. Example: If one project with a total budget of $100,000 is attributed as 50% effort in AFF, then the total investment is shown as $50,000. Totals in Figure 4 are shown in millions of dollars.

Figure 4. NIOSH investment in agriculture, forestry, and fishing research projects (FY2007 through FY2015)



Information on research associated with the cross-sector programs is available for FY2007 through FY2014. The cross-sector programs are described later in this supplement. Figure 5 shows the AFF research by cross-sector. A research project is counted if at least 50% of project activity is attributed to the AFF sector program and the corresponding cross-sector program. Cross-sector data are shown for five projects or more during the decade.

Figure 5. Number of projects by NIOSH cross-sector program in agriculture, forestry, and fishing (FY2007 through FY2014)

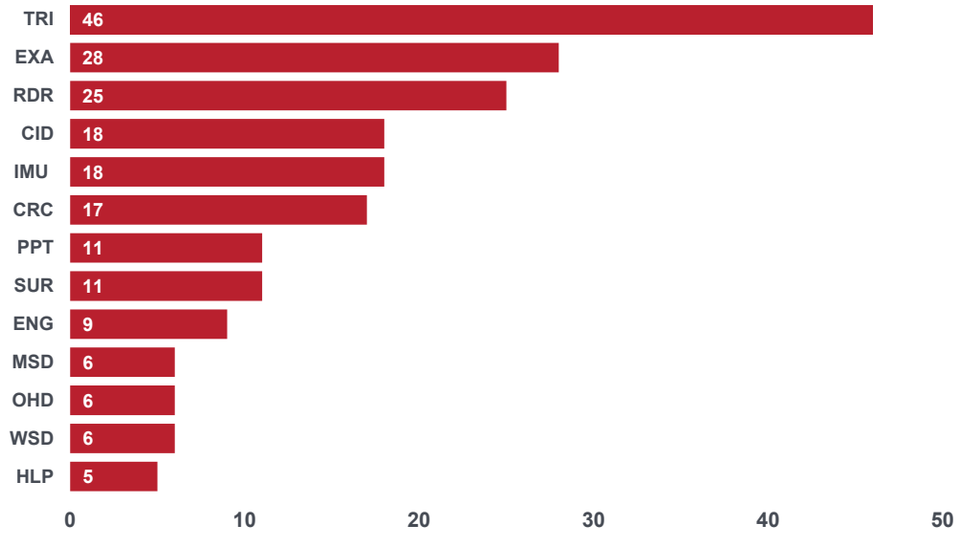


Table 1 shows the number and type of publications during the decade that were attributed to the AFF sector. Publications were identified in the NIOSHTIC-2 database of occupational safety and health publications, documents, grant reports, and other communication products supported in whole or in part by NIOSH funding. Publication counts likely underestimate publications produced by the program during NORA's second decade, due to the limitations of the data-collection methods available. Not all publications a program develops are in the NIOSHTIC-2 database, and not all publications in the database can be associated with a specific program. During the second decade, 459 publications were attributed to the AFF Sector Program, with an almost-even distribution between intramural publications (242) and extramural (240).

Table 1. Publications attributed to agriculture, forestry, and fishing by type (FY2007 through FY2014)

Publication type	Total number of Publications	Intramural publications	Extramural publications
Journal article	289	129	175
NIOSH-numbered publication or field study report	62	62	0
Abstracts of conference proceeding	59	34	25
Book or book chapter	8	6	3
Newsletter, trade, or lay publication	20	7	20
Other	21	4	17
Totals	459	242	240

Note: The sum of intramural and extramural publications may exceed the total. A publication with intramural and extramural authors is counted in both categories.

ROLLOVER PROTECTIONS

NIOSH, states, manufacturers, farm organizations, and individuals partnered to test, validate, and increase farmers' awareness of cost-effective roll-over protection systems to reduce risk of serious injury or death in a tractor overturn. NIOSH and partners also encouraged market incentives to install the systems.

BETTER BOAT DESIGN

NIOSH research on reducing boat workers' exposure to carbon monoxide led some boat manufacturers to improve their vessel design.

RISKS SOFTWARE MODEL

A NIOSH software model helps the U.S. Environmental Protection Agency identify work-related risks.

DANGEROUS CHEMICALS

NIOSH compiled findings identifying hazardous chemical exposure levels in its Current Intelligence Bulletin 66: Derivation of Immediately Dangerous to Life or Health. Stakeholders such as the American Industrial Hygiene Association, the American Society of Safety Engineers, and the World Health Organization adopted these findings to protect workers.

Effectiveness

One measure of research effectiveness is the degree to which research activities addressed strategic goals of the AFF Program. Information on the sector goals addressed by a project is available for some NIOSH research projects. Table 2 shows how many projects addressed each strategic goal during the decade. The most-frequently addressed strategic goal (SG) was SG 05 (Acute and Chronic Disease). SG 06 (Traumatic Injury in Forestry) and SG 07 (Acute and Chronic Disease in Forestry) were the least-frequently addressed strategic goal. Intramural research projects most-frequently addressed SG 05, followed by SG 03 (Implementing Effective Strategies), SG 02 (Vulnerable Populations), and SG 01 (Surveillance). Extramural projects most-frequently addressed SG 05, followed by SG 03, SG 02, and SG 04 (Traumatic Injury in Agriculture).

Table 2. Number of agriculture, forestry, and fishing research projects by strategic goal (FY2007 through FY2014)

Strategic Goal (SG)	Intramural Projects	Extramural Projects	Total Number of Projects
SG 01: Surveillance	16	8	24
SG 02: Vulnerable populations	17	18	35
SG 03: Implementing effective strategies	19	22	41
SG 04: Traumatic injury in agriculture	12	13	25
SG 05: Acute and chronic disease	23	40	63
SG 06: Traumatic injury in forestry	2	1	3
SG 07: Acute and chronic disease in forestry	2	1	3
SG 08: Traumatic injury in fishing	12	3	15
SG 09: Illness and disease in fishing	3	1	4

Data show how many research projects contributed 50% or more effort to the sector and addressing the indicated goal. Projects may address multiple goals.

Outcomes and Impact

Citation of NIOSH-funded journal articles is one measure of research outcomes. This indicates that scientists outside of NIOSH have used the institute's research outputs. Table 3 shows journal articles associated with the AFF sector, and their citation counts available in the Scopus citation database as of September 2016. Data are shown for publications resulting from intramural and extramural research. Journal article counts included in this table are lower than the total number noted in the publication table for this program. Not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

SILICA DUST PROTECTION

NIOSH information on preventing work-related silica exposure provided scientific information for the Occupational Safety and Health Administration's silica dust rule making.

Table 3. Number of citations for agriculture, forestry, and fishing

Type of Citation	Total Citations
Total number of journal articles	259
Total number of citations	4,175
Intramural journal articles	104
Intramural citations	1,798
Extramural journal articles	166
Extramural citations	2,628

Another important measure of research outcomes is how many outputs others have obtained. Table 4 shows how many NIOSH-numbered publications associated with the AFF sector have been requested in printed form or downloaded electronically during NORA's second decade.

Table 4. Electronic and printed distribution of NIOSH-numbered agriculture, forestry, and fishing publications (FY2007 through FY2014)

Sector	Number of Publications	Electronic Downloads	Printed Distribution
Agriculture, Forestry, and Fishing	61	116,647	1,509,384

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CONSTRUCTION


Photo by Thinkstock

The Construction Sector (CON) comprises establishments that build or renovate roads, houses, workplaces, and utilities. Construction workers face risks that include crashes involving motor vehicles, falls, musculoskeletal disorders, and chemical exposures.

The Construction Sector Council is a 45-member group comprising representatives from the following organizations:

- Federal (NIOSH and OSHA's Directorate of Construction) and state agencies (Kentucky Labor Cabinet, Massachusetts Department of Public Health, and Wisconsin Division of Public Health)
- Employee organizations (such as the International Union of Operating Engineers, Laborers Health and Safety Trust Fund, and Building and Construction Trades Department of the AFL-CIO)
- Employer organizations (such as the Associated General Contractors of America; American Road and Transportation Builders Association, National Association of Home Builders)
- Universities, professional organizations, and other entities

The NIOSH construction program closely partners with the many organizations represented on the sector council, as well as many other independent

Contractors Participate in National Falls Campaign and Safety Stand-down

Each year, falls kill more than 200 and seriously injure more than 10,000 construction workers. Construction falls are the leading fatalities and account for one-third of on-the-job deaths in the industry. These deaths and injuries are preventable. NIOSH, OSHA, the Center for Construction Research and Training (CPWR), and their partners sponsor the national construction falls prevention campaign in an effort to prevent fatal falls from roofs, ladders, and scaffolds. NIOSH and its partners use the campaign to encourage residential construction contractors to do the following:

- Plan ahead to get the job done safely
- Provide the right equipment for workers
- Train everyone to use the equipment safely
- The7879 campaign started in 2012.

An early evaluation indicated that information was not reaching small construction contractors, the primary target audience. Since then, reaching them has been a key focus. In 2013, the target of the campaign expanded to prevent falls in all types of construction. In 2014, a Safety Stand-down was added. Currently, more than 7,000 construction employers and more than 2.5 million construction employees participate in campaign events. Dozens of campaign leaders remain committed to this endeavor. NIOSH expects continued success.

Details: Campaign to Prevent Falls in Construction

BETTER FALL PROTECTION

NIOSH work contributed to a New Jersey mandate that state-funded contractors improve fall-protection measures.

TOTAL WORKER HEALTH®

NIOSH consulted with and assisted federal agency partners, such as Office of Personnel Management and Veterans Health Administration, to incorporate and advance the policies, programs, and practices of the NIOSH initiative known as Total Worker Health®.

groups. Two key construction partners are the Center for Construction Research and Training (CPWR), and the OSHA Construction Directorate.

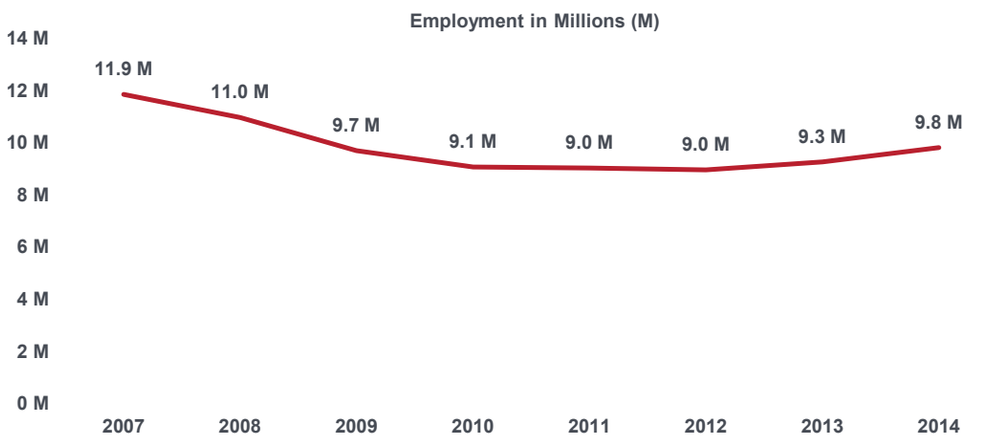
Construction sector leadership actively develops partnerships within NIOSH and among its external stakeholders, and it coordinates construction research and related activities among NIOSH divisions, labs, and offices. The NORA Construction Sector Council is a cohesive group that collaborates to advance safety and health for all construction workers. The sector council developed the National Construction Agenda, providing a vehicle by which construction industry stakeholders could describe the most relevant issues, gaps, and safety and health needs in the industry. The resulting agenda consists of 15 research strategic goals designed to address 10 top problems in construction safety and health for which significant progress has been made during NORA's past decade.

Trends in Construction Employment, Fatalities, Injuries, and Illnesses

Trends during the decade in employment, fatalities, and nonfatal injuries give context for the review of the CON sector activities, effectiveness, and impact. Background is also given on rates for employment in the sector, fatalities, and nonfatal injuries. From 2007 through 2014, employment in the CON sector declined from a high of almost 12 million in 2007 to under 10 million in 2014 (Figure 6). Employment data were collected from the Current Population Survey, which includes private industry and government (federal, state, and local) and the self-employed. Volunteers are not included in employment counts.

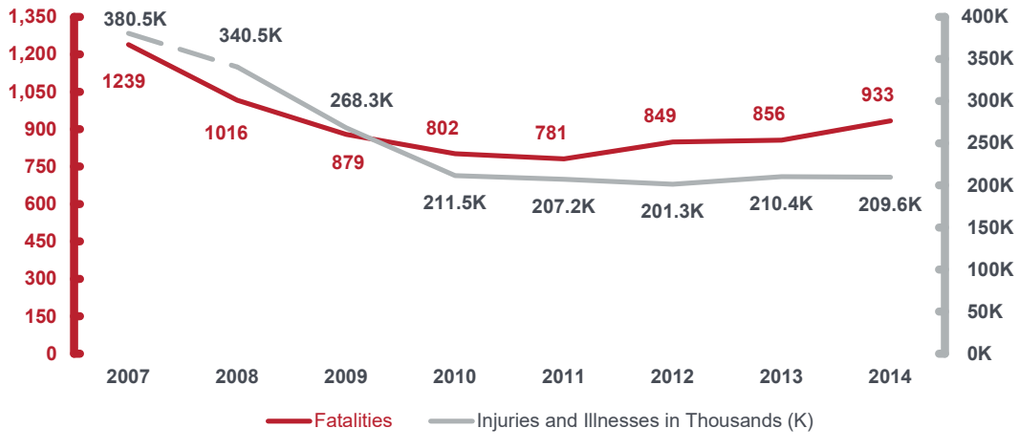
Fatalities in the construction industry declined during the decade, from a high of 1,239 deaths due to work-related events in 2007, to a low of 781 deaths in 2011. Fatalities then increased to 933 in 2014 (Figure 7). Nonfatal injuries (Figure 7) began the decade with 380,500 nonfatal injuries and illnesses in 2007. They significantly declined to nearly 212,000 in 2010, before leveling off. Fatality and injury data were collected from the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Injuries and Illnesses (SOII). The latter does not include self-employed, and only private industry data were available before 2008.

Figure 6. Employment trend in construction (2007 through 2014)



Employment data: Bureau of Labor Statistics, Current Population Survey (CPS).

Figure 7. Fatality, injury or illness trends in construction (2007 through 2014)

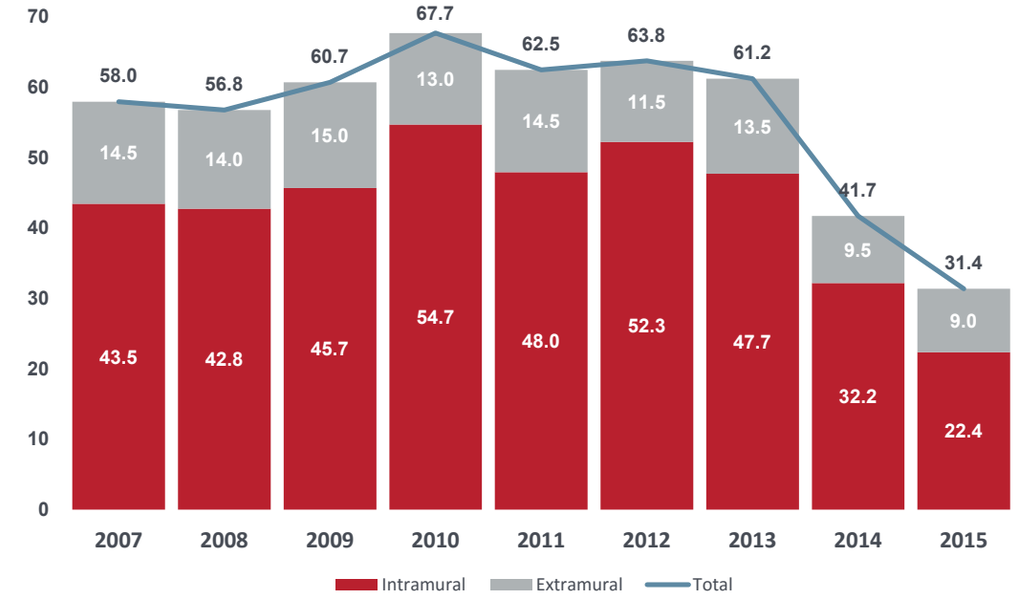


Fatality data: Bureau of Labor Statistics, Census of Fatal Occupational Injuries (CFOI). Injury or illness data: Bureau of Labor Statistics, Survey of Occupational Injuries and Illnesses (SOII).

Activities and Output

Figure 8 shows how many research projects (intramural and extramural) contributed effort to the Construction Sector Program during the decade. Project counts reflect the percentage of total effort directly attributable to CON Sector Program research. Example: If one project is attributed as 50% effort in the CON sector, it is counted as 0.50 of a project.

Figure 8. Number of construction research projects (FY2007 through FY2015)



PROTECTION FROM PCB

NIOSH work to protect school-renovation workers from exposure to the chemical polychlorinated biphenyl, or PCB, contributed to efforts by companies to reduce workers' exposure.

SKIN NOTATIONS

NIOSH developed a new strategy to prevent work-related chemical exposure of skin (Current Intelligence Bulletin 61: A Strategy for Assigning New NIOSH Skin Notations), which the American Industrial Hygiene Association, U.S. Navy, and the World Health Organization adopted.

HIGHWAY WORKER SAFETY

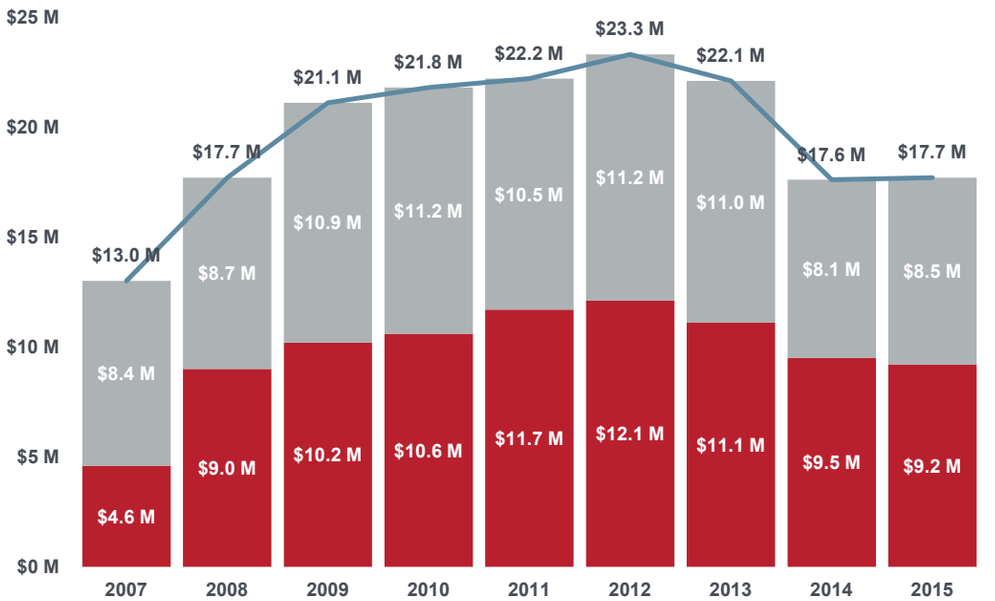
NIOSH work contributed to a new standard from the American National Standards Institute to protect highway construction workers (Standard A10.47, Work Zone Safety for Highway Construction).

NIOSH PPE TECHNOLOGY

At least one company commercialized NIOSH technology to allow multiple air sources to be attached to a self-rescuer respirator without breaking the seal and compromising performance.

Figure 9 shows the funds invested in intramural and extramural research projects from 2007 through 2015. Investment totals reflect the percentage of total effort directly attributable to CON Sector Program research. Example: If one project with a total budget of $100,000 is attributed as 50% effort in the CON sector, then the total investment is shown as $50,000. Totals in Figure 9 are shown in millions.

Figure 9. NIOSH investment in construction research projects (FY2007 through FY2015)



Information on research associated with the cross-sector programs is available for FY2007 through FY2014. The cross-sector programs are described later in this supplement. Figure 10 shows CON sector research by cross-sector. A research project is counted if at least 50% of project activity is attributed to the CON Sector Program and the corresponding cross-sector program. Cross-sector data are shown for five projects or more during the decade.

Figure 10. Construction: number of projects by NIOSH cross-sector program (FY2007 through FY2014)

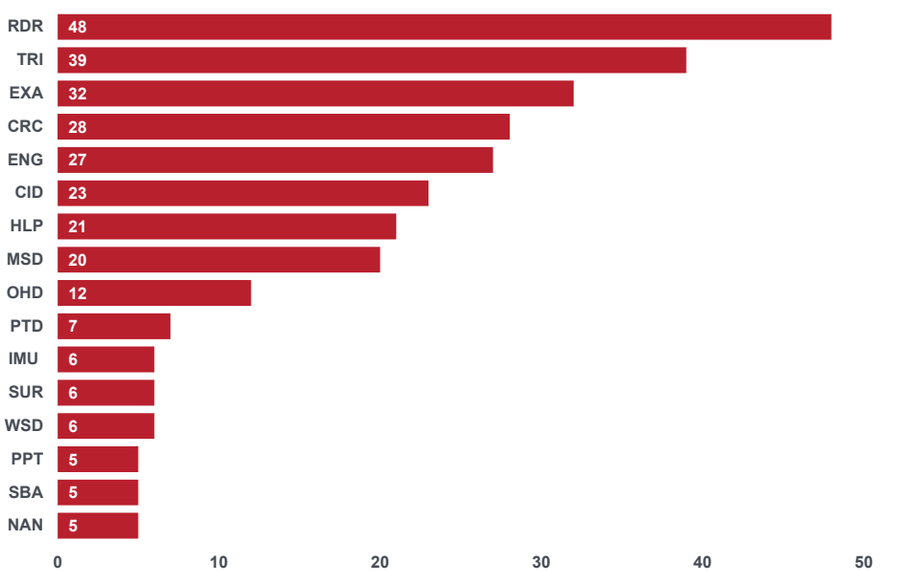


Table 5 shows the number and type of publications during the decade that were attributed to the CON sector. Publications were identified in the NIOSHTIC-2 database of occupational safety and health publications, documents, grant reports, and other communication products supported in whole or in part by NIOSH funding. Publication counts likely underestimate publications produced by the program during NORA second decade, due to the limitations of the data-collection methods available. Not all publications a program develops are included in the NIOSHTIC-2 database, and not all publications in the database can be associated with a specific program. During the second decade, 755 publications were attributed to the CON Sector Program, including intramural publications (544) and extramural (217).

Table 5. Publications attributed to the construction sector by type (FY2007 through FY2014)

Publication Category	Total Number Publications	Intramural Publications	Extramural Publications
Journal article	346	242	106
Numbered publication or field study report	108	108	0
Abstract or conference proceeding	162	132	32
Book or book chapter	28	22	6
Newsletter, trade, or lay publication	22	22	1
Other	89	18	72
Totals	755	544	217

Note: The sum of intramural and extramural publications may exceed the total. A publication with intramural and extramural authors is counted in both categories.

Effectiveness

One measure of research effectiveness is the degree to which research activities addressed strategic goals of the CON Program. Information on the sector goals addressed by a project is available for some NIOSH research projects. Table 6 shows how many projects addressed each strategic goal during the decade. The most-frequently addressed strategic goal (SG) was SG 05 (Silica). SG 02 (Fatal and Nonfatal Injuries from Contact with Electricity), SG 10 (Organization of the Industry) and SG 15 (Engage Media) were the least-frequently addressed strategic goal. SG 10 was inactive after 2010 and SG 15 was added in 2010. Intramural research projects most-frequently addressed SG 05, followed by SG 01 (Falls to a Lower Level), SG 04 (Reduce Hearing Loss), and SG 07 (Reduce Musculoskeletal Disorders). Extramural projects most-frequently addressed SG 07, followed by SG 12 (Vulnerable Populations).

HEARING LOSS TRAINING

NIOSH research on construction-related hearing loss helped the Occupational Safety and Health Administration develop an interactive, web-based training site to protect workers.

HARNESS PROTECTION

NIOSH research to prevent construction-related falls contributed scientific information to better worker protection when two manufacturers modified harness designs and developed new harnesses to prevent falls, and the American National Standards Institute updated its fall prevention and protection standards.

GUARD-RAIL SYSTEM

Manufacturers have shown interest in commercializing the patented NIOSH roof-bracket guard-rail system, and the Roofers' Union requested more than 100 additional brochures describing the system to distribute to instructors in the union's apprenticeship program.

WORKPLACE DESIGNS

NIOSH principles to protect workers through workplace design are included in a revised standard from the American National Standards Institute.

Table 6. Number of construction sector research projects by strategic goal (FY2007 through FY2014)

Strategic Goal (SG)	Intramural Projects	Extramural Projects	Total Number of Projects
SG 01: Falls to a lower level	18	4	22
SG 02: Fatal and nonfatal injuries from contact with electricity (inactive after FY2011)	3	0	3
SG 03: Struck-by incidents	11	5	16
SG 04: Reduce hearing loss	18	3	21
SG 05: Silica	24	5	29
SG 06: Welding fume exposures and risks	15	4	19
SG 07: Reduce musculoskeletal disorders	16	9	25
SG 08: Safety culture	10	5	15
SG 09: Safety and health management programs	7	5	12
SG 10: Organization of the industry (inactive after FY2011)	1	1	2
SG 11: Training and education	14	3	17
SG 12: Vulnerable populations	9	8	17
SG 13: Prevention through design	8	3	11
SG 14: Surveillance	8	2	10
SG 15: Engage Media (added FY2010)	1	0	1

Data show how many research projects contributed 50% or more effort to the sector and addressing the indicated goal. Projects can address multiple goals.

Outcomes and Impact

Citation of NIOSH-funded journal articles is one measure of research impact. This indicates that scientists outside of NIOSH have used the institute's research outputs. Table 7 shows journal articles associated with the CON sector and their citation counts available in the Scopus citation database as of September 2016. Data are shown for publications resulting from intramural and extramural research. Journal article counts included in this table are lower than the total number noted in the publication table for this program. Not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Table 7. Number of citations for construction

Type of Citation	Total
Total number of journal articles	299
Total number of citations	3,314
Intramural journal articles	207
Intramural citations	2,387
Extramural journal articles	94
Extramural citations	934

Note: Journal article counts included in this table are lower than the total number noted in the outputs table, because not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Another important measure of research outcomes how many outputs others have obtained. Table 8 shows how many NIOSH-numbered publications associated with the CON sector have been requested in printed form or downloaded electronically during NORA's second decade.

Table 8. Electronic and printed distribution of NIOSH-numbered construction sector publications (FY2007 through FY2014)

Sector	Number of Publications	Electronic Downloads	Printed Distribution
Construction	68	127,598	146,569

Considerable progress has been made on preventing falls in construction. Much of the progress has occurred through collaboration with OSHA, the Center for Construction Research and Training (CPWR), and many partners on the National Construction Falls Prevention Campaign and the National Safety Stand-Down. These partners include state health departments, private industry, trade associations, academia, and professional and labor organizations to spread the "Safety Pays Falls Cost" message. The campaign encourages residential and other construction contractors, workers, and others in the industry to work safely at heights and to use the right equipment. The activities led by the Campaign and Stand-Down Sector Council are rooted in research (such as an environmental scan, focus-group research in shaping the campaign, and evaluation of the campaign's effectiveness). The campaign began in 2012 and has continued to the present, increasing in size and scope every year. Sector council members contributed substantially to the supporting research, campaign fact sheets, and other supporting material. As part of the coordinated effort, CPWR hosts the main campaign website at Stop Construction Falls: Safety Pays, Falls Cost. Included in the 2014 re-launch, the national safety stand-down began and was expanded for 2 weeks in 2015 and 1 week in 2016. The stand-down raised awareness among employers and workers about fall hazards, which are the leading

WIPING LEAD AWAY

In 2007, a U.S. company offered a simple, reliable, NIOSH-developed wipe method to the healthcare market for removing lead contamination from the skin before collecting blood samples to measure blood lead levels. The method was also offered to the industrial market for removing lead contamination from skin and workplace surfaces.

FALLS FROM TOWERS

A NIOSH evaluation and other information about fatal falls from telecommunication towers contributed to the North Carolina Department of Labor releasing a new standard.

BUY QUIET CAMPAIGN

NIOSH studies and its Buy Quiet campaign contributed to an expanding market for quieter tools.

NEW CODING SYSTEM

NIOSH's new web-based Industry and Occupation Computerized Coding System (NIOCCS) speeds the standardized coding of industry and occupation into vital records, cancer registries, healthcare records, and other record systems. NIOCCS vastly improves the use of these sources for identifying the toll of work-related illnesses and injuries and identifying trends in types, numbers, and rates of occupational injury and illness for better prevention.

cause of deaths in the construction industry. Follow the National Safety Stand-Down at its website. Supporting intramural construction research and development efforts related to reducing falls in construction include the ladder safety app, harness design, mast-climbing work platforms, and use of a patented guardrail system. The campaign and stand-down won the 2016 NIOSH Bullard-Sherwood Award for excellence in research to practice.

Nail guns are a leading cause of injury among residential carpenters, and they are responsible for an estimated 37,000 emergency-room visits each year. NIOSH researchers have developed nail gun safety publications to guide workers on how to prevent the hazards. NIOSH took the lead role in working with OSHA to create co-branded guidance for contractors to address the NORA construction goal. NIOSH and OSHA developed a co-branded document, "Nail Gun Safety: A Guide for Construction Contractors." In 2013, NIOSH released an innovative publication, "Straight Talk About Nail Gun Safety," which is also available in Spanish.

The U.S. Green Building Council (USGBC) posted a new LEED pilot credit, "Prevention through Design," to its Leadership in Energy and Environmental Design (LEED) Pilot Credit Library in 2015. The pilot credit grew out of efforts motivated by a National Occupational Research Agenda (NORA) Construction goal to increase the use of Prevention through Design (PtD) in construction by integrating safety and health into green rating systems. NIOSH partnered with USGBC to build a relationship and to explore the connection between occupational safety and health and sustainable building practices. The credit is intended to reduce illnesses and injuries by supporting high-performance, cost-effective employee safety and health outcomes across the building lifecycle. This is accomplished by designing structures that reduce or eliminate potential safety and health hazards during two important building lifecycle phases—operations and maintenance, and construction.

In 2013, CPWR teamed with NIOSH and the NORA Construction Sector Council in planning and hosting a Safety Culture Workshop in Washington, DC. More than 70 industry thought leaders attended, along with a mix of government organizations, employers, associations, labor groups, academia, and safety and health professionals. In 2014, a report stemming from that workshop, "Safety Culture and Climate in Construction: Bridging the Gap between Research and Practice" [Gillen et al. 2014], was made available at CPWR's website. A CPWR booklet with eight fact sheets on key elements identified at the workshop has been developed. This material now includes "how to" guides for small business applications.

Noise-induced hearing loss is one of the most common work-related illnesses in the United States. NIOSH launched the national Buy Quiet Campaign in 2014 to raise awareness of the importance of manufacturing and purchasing quieter equipment. Buy Quiet encourages companies to seek out and demand quieter equipment, thus driving the market to design and create quieter products. In the long run, investment in noise controls should be more prevalent as the market demands quieter products. This paradigm occurs as the market for quieter products expands both from the supply side (manufacturers) and the demand side (tool and equipment purchasers). The key to reducing costs and increasing the benefits of Buy Quiet involves partnerships between

manufacturers and consumers. Buy Quiet initiatives in the construction industry include multimedia products (such as a short video, posters, and links to partner websites), as well as the noise profile database on power tools. The materials highlight the benefits of a Buy Quiet program and explain how companies can establish an effective program in the workplace. This effort has been highlighted through a roundtable discussion at the 2015 American Industrial Hygiene Association Conference and Expo, as well as through webinars that were cosponsored by NIOSH and CPWR.

Construction Sector researchers played key roles in supporting the proposed Occupational Safety and Health Administration (OSHA) silica standard in 2014 [OSHA 2016] and development of Table 1 concerning exposure-control methods. During the hearings, NIOSH researchers addressed the health effects of respirable crystalline silica exposure, along with sampling and analytical methods, and they shared their extensive research on engineering controls (including the highly successful asphalt milling partnership). This partnership resulted in widespread adoption of new engineering controls for silica on all new milling machines, and development of two important publications. One is a new publication, Best Practice Engineering Control Guidelines to Control Worker Exposure to Respirable Crystalline Silica During Asphalt Pavement Milling, which gives best practices, and the other is "Field Guide for Controlling Silica Dust Exposure on Asphalt Pavement Milling Machines." NIOSH has conducted wide-ranging basic and applied research on silica, along with prevention partnerships and cooperative agreements with government, industry, labor, and academia.

MONITORING HEARING

NIOSH efforts to prevent work-related hearing loss led to the American College of Occupational and Environmental Medicine and the Department of the Interior adopting the Institute's recommendation to use the 8 kHz frequency to monitor workers.

SURVEY QUESTIONS

Several states added Industry/Occupation questions to their state's version of the Behavioral Risk Factor Surveillance System (BRFSS) in 2012 based on NIOSH recommendations.

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HEALTHCARE AND SOCIAL ASSISTANCE


Photo by Thinkstock

The Healthcare and Social Assistance (HSA) Sector comprises such establishments as offices of physicians and other healthcare providers, hospitals, and nursing and residential care facilities. The sector also includes social assistance establishments that provide individual and family services, along with community food and housing. Also covered by the sector are emergency services, vocational rehabilitation services, and child day-care services. HSA workers face risks that include infectious diseases, workplace violence, overexertion, chemicals, shift work, and psycho-social stressors.

Over the past decade, the Healthcare and Social Assistance Program has worked with many exceptional and dedicated intramural and extramural partners. Intramural partners have represented multiple divisions, labs, and offices from NIOSH and CDC's Division of Healthcare Quality Promotion (DHQP), and extramural partners have represented healthcare employers, labor unions, academia, governmental agencies, and professional practice organizations.

The HSA Program has used an organized, logical, step-by-step approach to address the most pressing problems of the sector. One of the first actions of the HSA Council was to develop a "State-of-the-Sector" report outlining knowledge gaps and research needs for the sector. Using this report, the

Online Training Helps Protect Nurses and Others from Workplace Violence

Healthcare workers in private industry reported 9,200 nonfatal workplace violence injuries in 2013. That was more than 67% of the total number in all industries, although the healthcare industry employed only 11.5% of the U.S. workforce. Many healthcare workers do not get formal training in workplace violence prevention. However, they still face assault risks while working close to people in tense and often-stressful situations.

The NIOSH Workplace Violence Prevention for Nurses online training course offers free instruction designed to meet the needs of today's generation of workers. The course incorporates lesson text, videos depicting actual workplace violence incidents, and testimonials from nurses. Healthcare workers can access information regarding workplace violence awareness, risk factors, and prevention strategies through any device with an Internet connection. Upon completing the 13-unit course, nurses and other healthcare professionals can receive free continuing education credits (CEUs).

From the time the course became available in August 2013 through December 2015, about 14.9 thousand individuals completed the course. Most healthcare professionals earned education credits. Healthcare facilities and nursing schools are evaluating whether the course can be adapted for ongoing educational offerings.

Details: Online Training Helps Protect Nurses and Other Healthcare Workers From Workplace Violence, and Occupational Violence

DISINFECTANT SAFETY

NIOSH recommendations adopted by healthcare facilities help protect workers by reducing exposure to disinfectants that can cause health problems.

council developed a research agenda for the nation to address the sector's most important issues. The agenda first focused on five strategic goals (goals specific to veterinary medicine were added later). The first strategic goal was to promote safe and healthy workplaces and optimize safety culture in healthcare organizations. Accomplishments included partnering with The Joint Commission (TJC) to produce the monograph, Improving Patient and Worker Safety: Opportunities for Synergy, Collaboration, and Innovation, drawing attention to the need to create a culture that focuses on both patient and worker safety. Work involved a national call that solicited effective or innovative safety practices to protect both patients and workers. The monograph was globally disseminated to healthcare organizations and interested parties. A second accomplishment was an online training course, "Workplace Violence Prevention for Nurses," developed by NIOSH in response to a need to educate nurses on how to recognize, prevent, and respond to workplace violence. Since August 2013, more than 12,000 nurses have completed the training. A third accomplishment was the training course, "NIOSH Training for Nurses on Shift Work and Long Work Hours."

The second strategic goal was to reduce the incidence and severity of musculoskeletal disorders and injury events associated with slips, trips, and falls among healthcare workers. Using NIOSH research in this area, the American Nurses Association (ANA) unveiled national standards for safe patient handling and mobility that are designed to infuse a stronger culture of safety in healthcare work environments and provide a universal foundation for policies, practices, regulations, and legislation to protect patients and healthcare workers from injury. The ANA publication, Safe Patient Handling and Mobility: Interprofessional National Standards [ANA 2013], was developed by an interdisciplinary group including NIOSH researchers. In the wake of NIOSH efforts, 11 states have enacted safe patient-handling laws. The work inspired a National Public Radio (NPR) investigative report on safe patient-handling that reached an audience of 1.8 million listeners of "All Things Considered." Subsequently, OSHA launched a new initiative to investigate safe patient-handling among nurses in hospitals

The third strategic goal was to reduce or eliminate exposures and adverse health effects caused by hazardous drugs and other chemicals. NIOSH work in this area, including a NIOSH Hazardous Drugs List, has raised awareness of potential hazards workers face, and the need for exposure controls. Similarly, a NIOSH Survey of healthcare workers who handle hazardous drugs and other chemicals has documented lack of adherence to safe handling practices and opportunities for health protection. Also, an interdisciplinary work group of the council developed a multidisciplinary report on the state of the science and directions for future research in cleaning and disinfecting agents.

The fourth and fifth strategic goals addressed related issues of reducing sharps injuries and their impacts among all healthcare personnel and stopping transmission of infectious diseases in HSA settings among workers, patients, and visitors. NIOSH developed regulations implementing Part G of the Ryan White Act. NIOSH has carried out a range of activities to advance worker protection from influenza. NIOSH has worked with others to address a range of challenges, including pandemic influenza, Middle East Respiratory Syndrome (MERS),

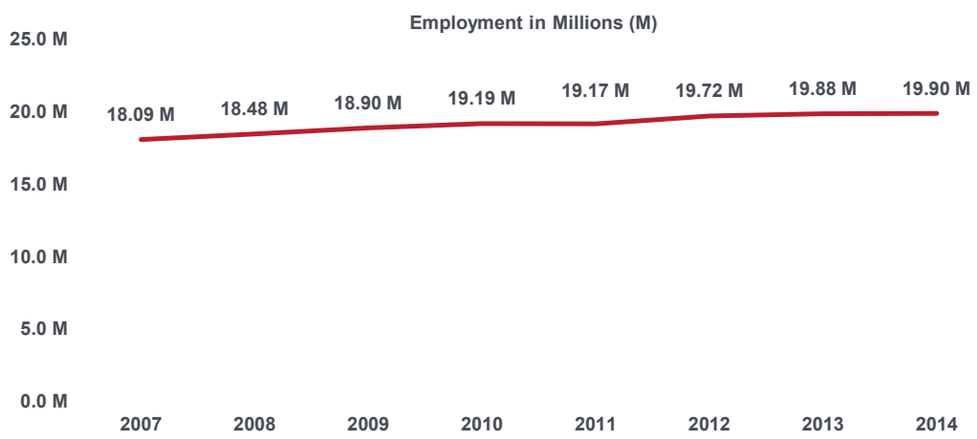
and Ebola Virus Disease. An important area of contribution has been in personal protective devices. NIOSH helped with a TJC monograph, Implementing Hospital Respiratory Protection Programs: Strategies from the Field and partnered to produce the NIOSH-OSHA Hospital Respiratory Protection Toolkit. Both of these resources were developed to help hospitals implement effective respiratory protection programs with an emphasis on preventing transmission of infectious diseases to healthcare personnel.

Trends in HSA Employment, Fatalities, Injuries, and Illnesses

Trends in employment, fatalities, and nonfatal injuries provide context for the review of the HSA activities, effectiveness, and impact during the decade. Background rates for employment in the sector, fatalities, and nonfatal injuries are provided. From 2007 through 2014, employment in the HSA sector increased from just more than 18 million in 2007 to almost 20 million in 2014 (Figure 11). Employment data were collected from the Current Population Survey and includes private industry and government (federal, state, and local) and the self-employed. Volunteers are not included in employment counts.

Figure 12 shows how many fatalities and nonfatal injuries and illnesses occurred from 2007 through 2014. The number of fatalities in the HSA sector during the decade has remained fairly stable, with 118 work-related deaths in 2007, to 111 fatalities in 2014. Nonfatal injuries increased from 675,700 in 2007 to a peak in 2009, before ending in 2014 at 710,200 (Figure 12). Fatality and injury data were collected from the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Injuries and Illnesses (SOII). The latter does not include self-employed, and only private industry data were available before 2008.

Figure 11. Employment trend in healthcare and social assistance (2007 through 2014)



Employment data: Bureau of Labor Statistics, Current Population Survey (CPS).

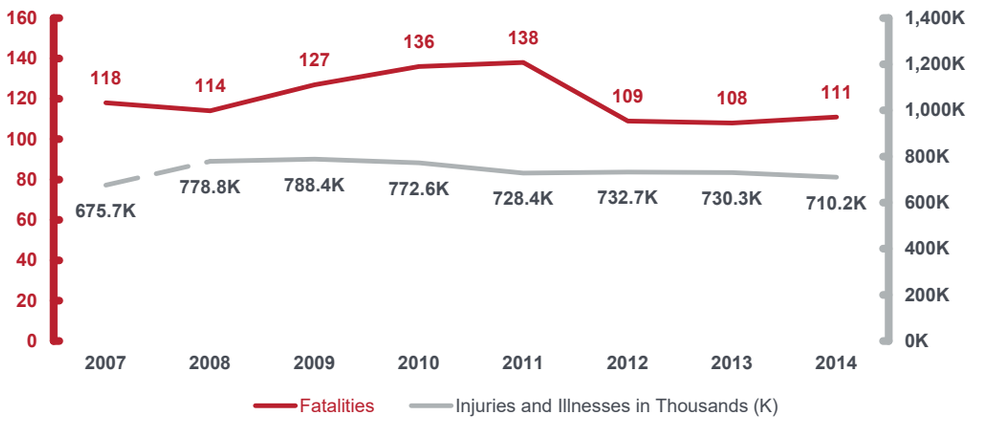
HOME HEALTHCARE

NIOSH recommendations adopted by the Occupational Safety and Health Administration help improve the health and safety of home healthcare workers.

RESPIRATOR HEALTH

NIOSH studies of health effects related to filtering face-piece respirators contributed to new guidance from national and international groups, including the World Health Organization, the Food and Drug Administration, and the Institute of Medicine.

Figure 12. Fatality, injury or illness trends in healthcare and social assistance (2007 through 2014)



Fatality data: Bureau of Labor Statistics, Census of Fatal Occupational Injuries (CFOI). Injury or illness data: Bureau of Labor Statistics, Survey of Occupational Injuries and Illnesses (SOII).

Activities and Output

Figure 13 shows how many research projects (intramural and extramural) contributed effort to the HSA Sector Program during the decade. Project counts reflect the percentage of total effort directly attributable to HSA Sector Program research. Example: If one project is attributed as 50% effort in HSA, then it is counted as 0.50 of a project.

Figure 13. Number of healthcare and social assistance research projects (FY2007 through FY2015)

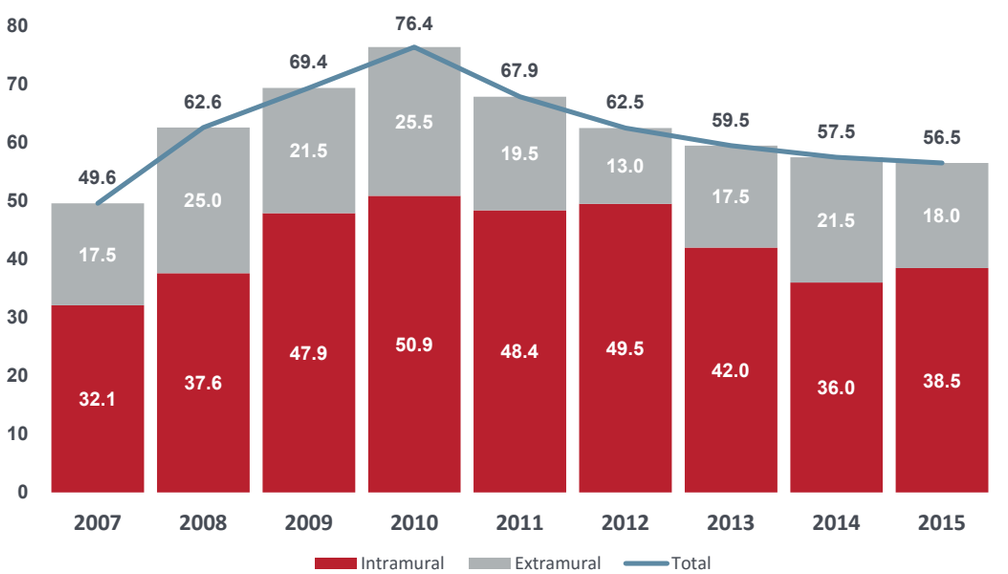
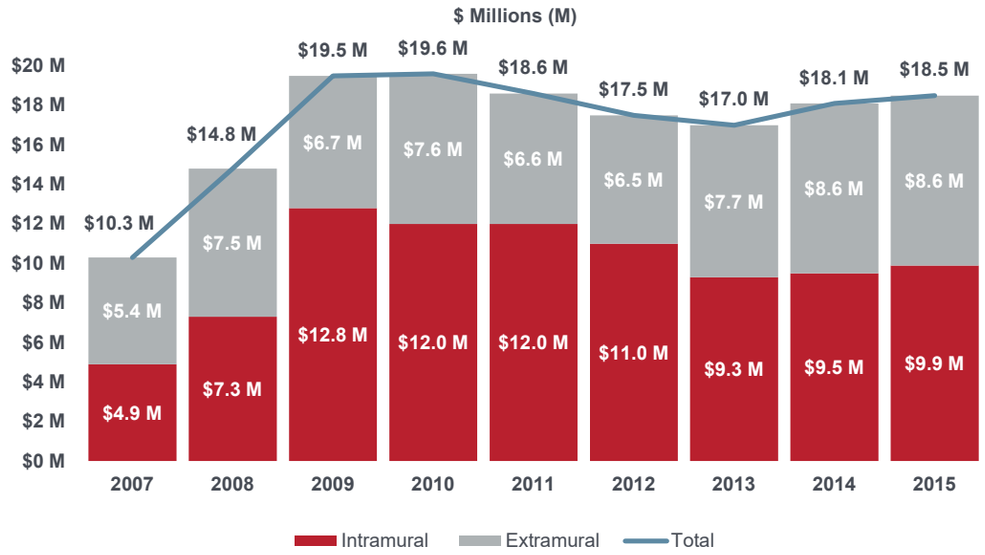


Figure 14 shows the funds invested in intramural and extramural research projects from 2007 through 2015. Investment totals reflect the percentage of total effort directly attributable to HSA Sector Program research goals. Example: If

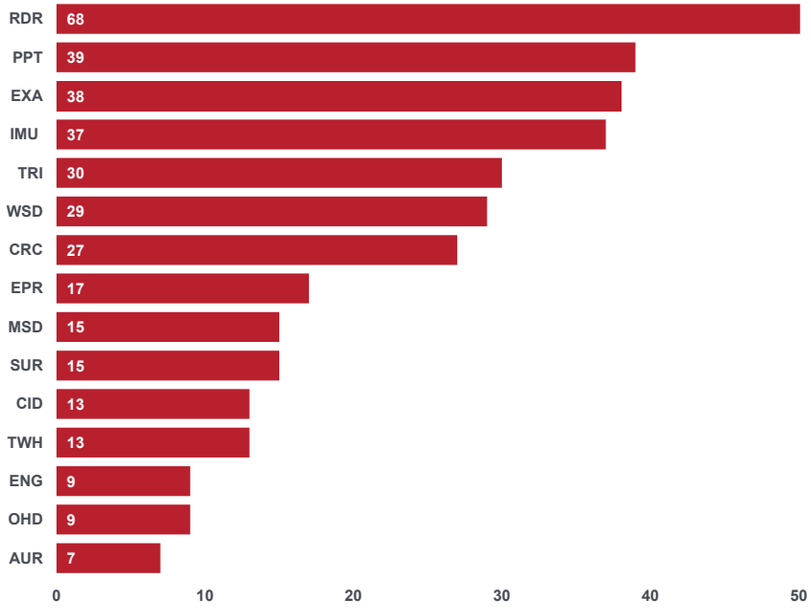
one project with a total budget of $100,000 is attributed as 50% effort in HSA, then the total investment is shown as $50,000. Totals in Figure 14 are shown in millions of dollars.

Figure 14. NIOSH investment in healthcare and social assistance research projects (FY2007 through FY2015)



Information on research associated with the cross-sector programs is available for FY2007 through FY2014. The cross-sector programs are described later in this supplement. The graph below shows the HSA research by cross-sector. A research project is counted if at least 50% of project activity is attributed to the HSA Sector Program and the corresponding cross-sector program. Cross-sector data are shown for five projects or more during the decade.

Figure 15. Number of projects in healthcare and social assistance by NIOSH cross-sector program (FY2007 through FY2014)



NURSE SAFETY STATEMENT

NIOSH suggestions contributed to an American Nurses Association's position statement to improve health and safety for nurses ("Addressing Nurse Fatigue to Promote Safety and Health: Joint Responsibilities of Registered Nurses and Employers to Reduce Risks").

NEEDLE-STICK REGULATIONS

NIOSH research to protect healthcare workers contributed to needle-stick regulations in 21 states; new regulations on safe patient handling in 11 states; and new standards on safe patient handling at the American Nurses Association.

Table 9 shows the number and type of publications during the decade that were attributed to the HSA Sector. Publications were identified in the NIOSHTIC-2 database of occupational safety and health publications, documents, grant reports, and other communication products supported in whole or in part by NIOSH funding. Publication counts likely underestimate publications produced by the program during NORA's second decade due to the limitations of the data-collection methods available. Not all publications a program develops are included in the NIOSHTIC-2 database, and not all publications in the database can be associated with a specific program. During the second decade, 492 publications were attributed to the HSA Sector Program, with an almost-even distribution between intramural publications (325) and extramural (174).

Table 9. Publications attributed to healthcare and social assistance by type (FY2007 through FY2014)

Publication Category	Total Number Publications	Intramural Publications	Extramural Publications
Journal article	261	176	91
Numbered publication or field study report	69	69	0
Abstract or conference proceeding	63	40	23
Book or book chapter	26	21	6
Newsletter, trade, or lay publication	34	5	29
Other	39	14	25
Totals	492	325	174

Note: The sum of intramural and extramural publications may exceed the total. A publication with intramural and extramural authors is counted in both categories.

Effectiveness

One measure of research effectiveness is the degree to which research activities addressed strategic goals of the HSA Program. Information on the sector goals addressed by a project is available for some NIOSH research projects. The HSA Program established strategic goals in FY2009. These goals were later revised, and new goals were introduced in FY2011. Five more goals were introduced in FY2014, which was outside of the review period of FY2007 through FY2014. Table 10 shows how many projects addressed each strategic goal during the decade. The most-frequently addressed strategic goal (SG) was SG 03 (Hazardous Drugs). The least-frequently addressed goals (SG 06–SG 10) were added to the HSA research agenda in 2014, so counts of projects addressing these goals by 2014 do not accurately reflect the effectiveness of the HSA research program in addressing strategic goals. Intramural research projects most-frequently addressed SG 03 (Hazardous Drugs and Chemicals Exposure), followed by SG 05 (Infectious Disease), SG 01 (Safety Culture), and SG 02 (Reduce Musculoskeletal Disorders). Extramural projects most-frequently addressed SG 01 (Safety Culture), followed by SG 02 and SG 05.

Table 10. Number of healthcare and social assistance research projects by strategic goal (FY2007 through FY2014)

Strategic Goal (SG)*	Intramural Projects	Extramural Projects	Total Number of Projects
SG 01: Safety culture (Added FY2011)	47	25	72
SG 02: Reduce musculoskeletal disorders (Added FY2011)	44	15	59
SG 03: Hazardous drugs and chemicals exposure (Added FY2011)	71	6	77
SG 04: Sharps injuries (Added FY2011)	15	8	23
SG 05: Infectious disease (Added FY2011)	62	12	74
SG 06: Zoonotic diseases among VM/AC [Implemented FY2014]†	2	1	3
SG 07: Injuries among VM/AC (Implemented FY2014)†	0	0	0
SG 08: Respiratory hazards among VM/AC (Implemented FY2014)†	0	0	0
SG 09: Reproductive hazards among VM/AC (Implemented FY2014)†	0	0	0
SG 10: Physical hazards among VM/AC (Implemented FY2014)†	0	0	0

*Data show how many research projects contributed 50% or more effort to the sector and addressing the indicated goal. Projects can address multiple goals.

†Five HSA goals were developed in FY2013 and implemented in FY2014, which was the end of the data-collection period. No projects during the data-collection period addressed four of these five new goals.

Outcomes and Impact

Citations of NIOSH-funded journal articles are one measure of research impact. This indicates that scientists outside of NIOSH have made use of the institute's research outputs. Table 11 shows journal articles associated with the HSA sector and their citation counts available in the Scopus citation database as of September 2016. Data are shown for publications resulting from intramural and extramural research. Fewer journal articles are included in this table than the total number noted in the publication table for this program. Not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

VIOLENCE PREVENTION

NIOSH-developed training modules on preventing workplace violence help protect workers by instructing nursing students on how to prevent workplace violence and contributing to the state of New Jersey enacting a law to help protect workers.

HEARING LOSS SIMULATOR

NIOSH developed a Hearing Loss Simulator (HLS), a software training and communication tool that demonstrates the effects of noise exposure on a worker's hearing without exposure to harmful noise levels. The real-life scenarios of this software are designed to raise awareness, increase motivation for hearing loss prevention, and reduce the number of people who suffer from hearing loss. OSHA and other organizations are utilizing and recommending the HLS.

Table 11. Number of citations attributed to healthcare and social assistance (FY2007 through FY2014)

Type of Citation	Totals
Total number of journal articles	213
Total number of citations	2,686
Intramural journal articles	140
Intramural citations	1,786
Extramural journal articles	79
Extramural citations	1,048

Note: Journal article counts included in this table are lower than the total number noted in the outputs table, because not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Another important measure of research outcomes is how many outputs others have obtained. Table 12 shows how many NIOSH-numbered publications associated with the HSA sector that have been requested in printed form or downloaded electronically during NORA's second decade.

Table 12. Electronic and printed distribution of NIOSH-numbered healthcare and social assistance publications

Sector	Number of Publications	Electronic Downloads	Printed Distribution
Healthcare and Social Assistance	57	288,458	422,749

MANUFACTURING

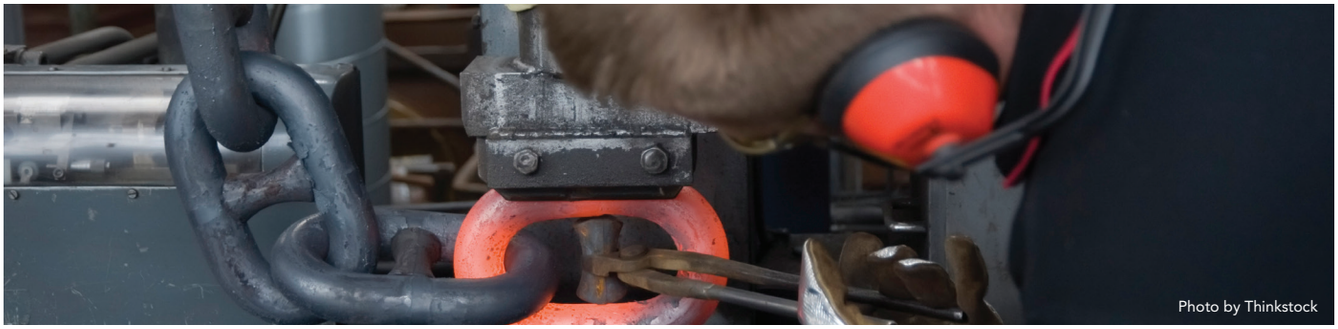


Photo by Thinkstock

The Manufacturing (MNF) Sector comprises establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products. Manufacturing faces a wide range of diversity in workplace and safety challenges. Hearing loss, nanotechnology, chemical process safety, management systems, and special populations are some of the priority research needs.

The Manufacturing Program includes representatives of NIOSH divisions and external organizations (academia, trade or professional organizations, industry, insurers, unions, and government). These diverse parties collaborate to identify and address the most-critical issues in workplace safety and health in manufacturing, through research and non-research activities. The Manufacturing Program has been able to expand NIOSH's research portfolio and improve the dissemination of NIOSH products and initiatives through cooperative efforts with outside partners and NORA Cross-sectors.

New constituencies were reached through dedicated sessions in scientific and trade show events, publications, and other efforts to make scholarly communication systems more nimble and accessible. Examples include an annual dedicated research-to-practice track at a large safety event (National Safety Council) and working

Wind Blade Manufacturer Reduces Styrene Exposures

Managers at a plant that manufactures wind turbine blades asked for NIOSH assistance. Previous air sampling raised concerns about peak styrene concentrations when workers enter the confined space inside of the wind turbine blade to perform a glue-wiping task. Overexposure to high levels of styrene can cause death or irreparably damage a worker's health. At lower levels, styrene can damage the central nervous system and accelerate loss of hearing due to noise exposure. NIOSH researchers made two site visits, measuring the styrene concentration in the air near the workers as they performed manufacturing tasks. NIOSH confirmed the glue-wiping task has the highest exposures. NIOSH recommended that exposures be controlled, and it published reports describing the study.

After the initial site visit, the company made changes to the glue-wipe task that eliminated the need for workers to enter the confined space inside of the wind-turbine blade. Styrene exposures were reduced by an order of magnitude. The company considered more NIOSH recommendations to further reduce styrene and other potentially hazardous exposures. The NIOSH work underscores the need to address worker safety and health issues in the growing clean-energy industries.

Details: Occupational Exposures to Styrene Vapor in a Manufacturing Plant for Fiber-Reinforced Composite Wind Turbine Blades

NEW HEARING MEASURES

A NIOSH study with boat manufacturers led to several manufacturers reducing styrene and noise exposure with engineering controls.

SAFETY, HEALTH TRAINING

Maryland's local occupational health faculty members use the new NIOSH-funded state-based Occupational Health and Safety Surveillance Program indicators website to teach about occupational safety and health.

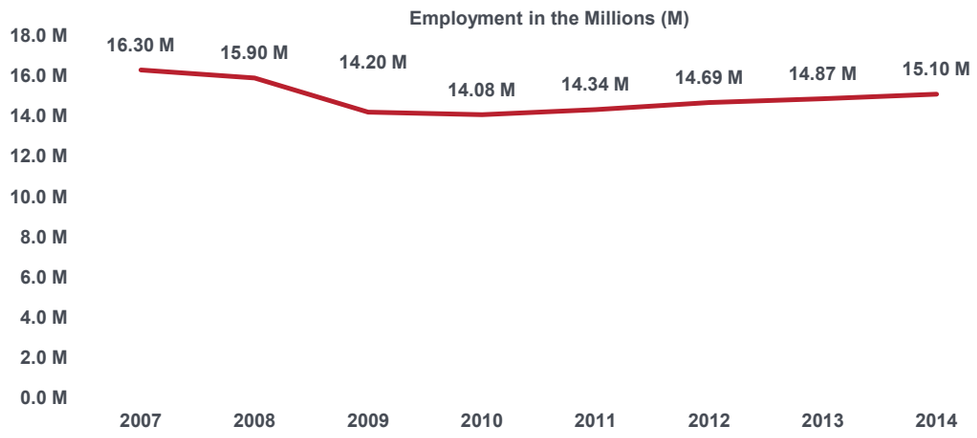
with stakeholders to coauthor NIOSH Science Blog articles on some of the sector's strategic goals. The science blog articles helped NIOSH to evaluate reach, including press presence and other metrics.

The National Manufacturing Agenda was developed and disseminated in August 2009. It has guided the funding of high-quality research, and several projects have benefitted from the national partnerships developed through the Manufacturing Sector Council. From 2007 through 2014, nearly a third (31%) of all NIOSH publications had implications for the manufacturing industry. In addition, 12% of the publications by extramural researchers also addressed manufacturing. Highlights include contributions made to encourage research and improve the dissemination of research results related to preventing traumatic injury, musculoskeletal disorders, respiratory disease, cancer, and hearing loss. Other important highlights were outreach to small business and activities involving nanotechnology. An example was publication of research analyzing saw-related injuries and their causes, compared with national data from the Bureau of Labor Statistics. NIOSH-recommended practices to prevent hearing loss were adopted by organizations that include the National Institute of Standards and Technology, OSHA (for training of its field inspectors), the Department of Defense (for its new regulation, DODI 1474E, [DOD 2015]), and the National Academy of Engineering's Technology for a Quieter America (TQA) Workgroup. A further highlight was giving guidance to reduce exposure to nanomaterials at the source. Beyond research, the council contributed to transferring and translating research findings, technologies, and information into guidance and products that help prevent worker injuries and illnesses. The council partnered with the University of Cincinnati's Department of Environmental Health and Education and Research Center to organize a NORA Manufacturing Sector Conference in September 2011 in Cincinnati, Ohio. The conference helped to set priorities and create partnerships to improve occupational safety and health in manufacturing. Since then, the council has worked to expand and expedite how new information and technologies can be communicated to the public as soon as they are developed. Using new media and metrics, the council has worked to improve networking, and it addressed disseminating evidence-based recommendations to inform decision-making parties in occupational health.

Trends in Manufacturing Employment, Fatalities, Injuries, and Illnesses

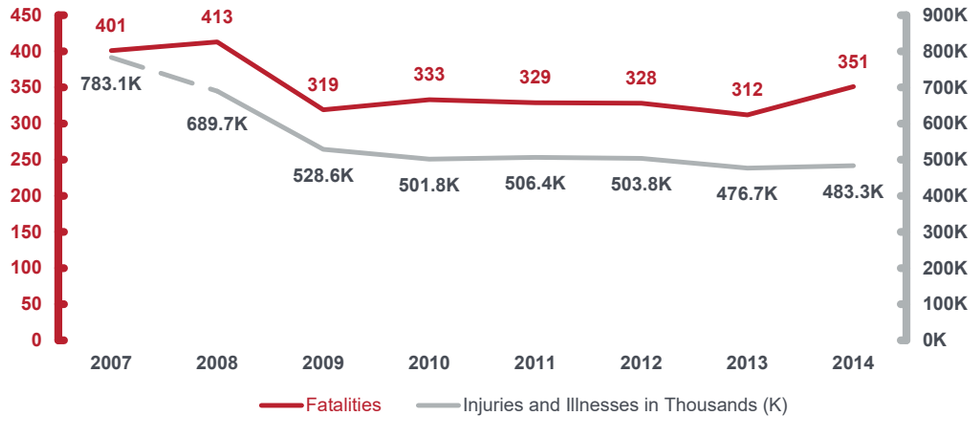
Figure 16 and Figure 17 show trends in employment, fatalities, and nonfatal injuries and illnesses. Manufacturing employment declined from a high of more than 16 million in 2007 to a little more than 15 million in 2014 (Figure 16). Fatalities dropped slightly during the same period, from 401 in 2007 to a low of 312 in 2013, before slightly rising to 351 in 2014 (Figure 17). Nonfatal injuries and illnesses were sharply reduced during the decade, from around 783,000 in 2007 to a low of nearly 477,000 in 2013 (Figure 17). Fatality and injury data were collected from the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Injuries and Illnesses (SOII). The SOII does not include the self-employed, and only private industry data were available before 2008.

Figure 16. Employment trend in manufacturing (2007 through 2014)



Employment data: Bureau of Labor Statistics, Current Population Survey (CPS).

Figure 17. Fatality, injury or illness trends in manufacturing (2007 through 2014)



Fatality data: Bureau of Labor Statistics, Census of Fatal Occupational Injuries (CFOI). Injury or illness data: Bureau of Labor Statistics, Survey of Occupational Injuries and Illnesses (SOII).

Activities and Output

Figure 18 shows how many research projects (intramural and extramural) contributed effort to the MNF Sector Program during the decade. Project counts reflect the percentage of total effort directly attributable to MNF Sector Program research. Example: If one project is attributed as 50% effort in MNF, then it is counted as 0.50 of a project.

ANTI-VIBRATION GLOVES

NIOSH research on preventing hand-arm vibration syndrome contributed scientific information to new national standards for testing and certifying anti-vibration gloves, to the General Services Administration recommending that gloves be certified and to the LeBlanc Building Co. incorporating a hand-tool document in its employee training.

CLAIMS DATA USE

NIOSH recommendations for preventing diseases, identified through medical claims data, provide information that health insurers use to develop reports and that employers use to develop priorities and prevention plans.

BIOMECHANICS DATA

The NIOSH model for work-related biomechanics (6DHAND) provided information that the company BioMotion of America used to develop protocols for when workers can return to work after an injury.

DIACETYL SAMPLING

NIOSH research validated the Occupational Safety and Health Administration's way of sampling for the flavoring diacetyl. More researchers and industrial hygienists are now using that approach.

Figure 18. Number of manufacturing projects (FY2007 through FY2015)

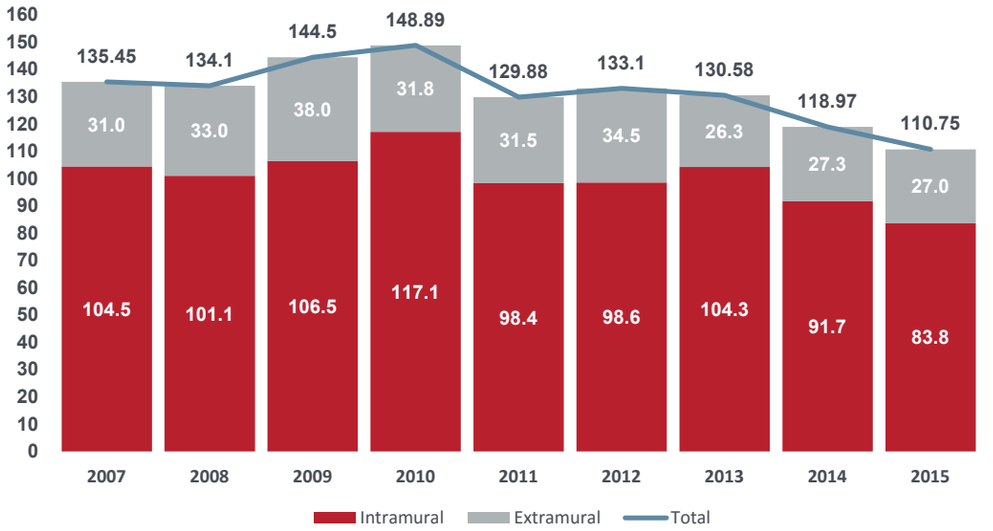
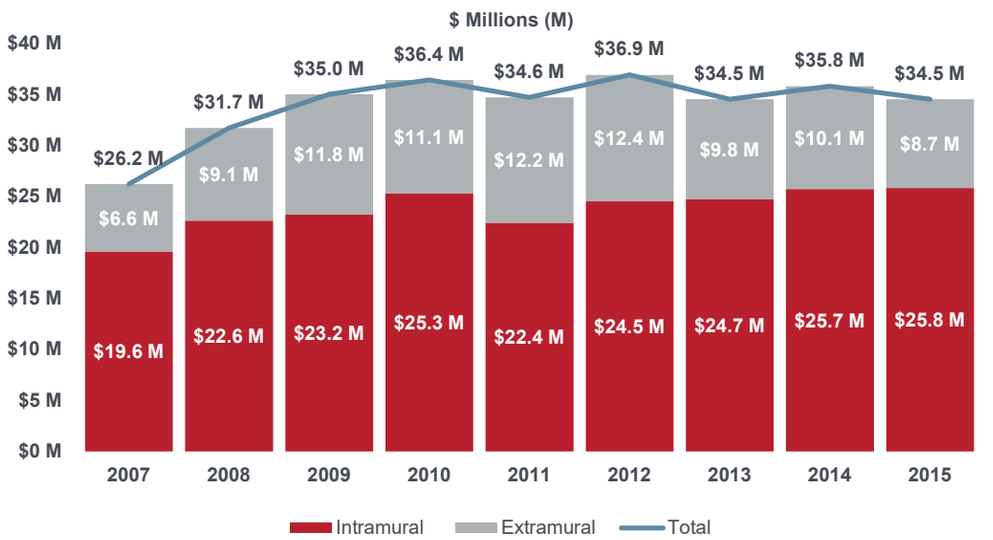


Figure 19 shows funds invested in intramural and extramural research projects from 2007 through 2015. Investment totals reflect the percentage of total effort directly attributable to MNF Sector Program research goals. Example: If one project with a total budget of $100,000 is attributed as 50% effort in MNF, then the total investment is shown as $50,000. Totals are shown in millions of dollars.

Figure 19. NIOSH investment in manufacturing research projects (FY2007 through FY2015)



Information on research associated with the cross-sector programs is available from FY2007 through FY2014. The cross-sector programs are described later in this supplement. Figure 20 shows the MNF research by cross-sector. A research project is counted if at least 50% of project activity is attributed to the MNF Sector Program and the corresponding cross-sector program. Cross-sector data are shown for five projects or more during the decade.

Figure 20. Number of projects by NIOSH cross-sector program for manufacturing (FY2007 through FY2014)

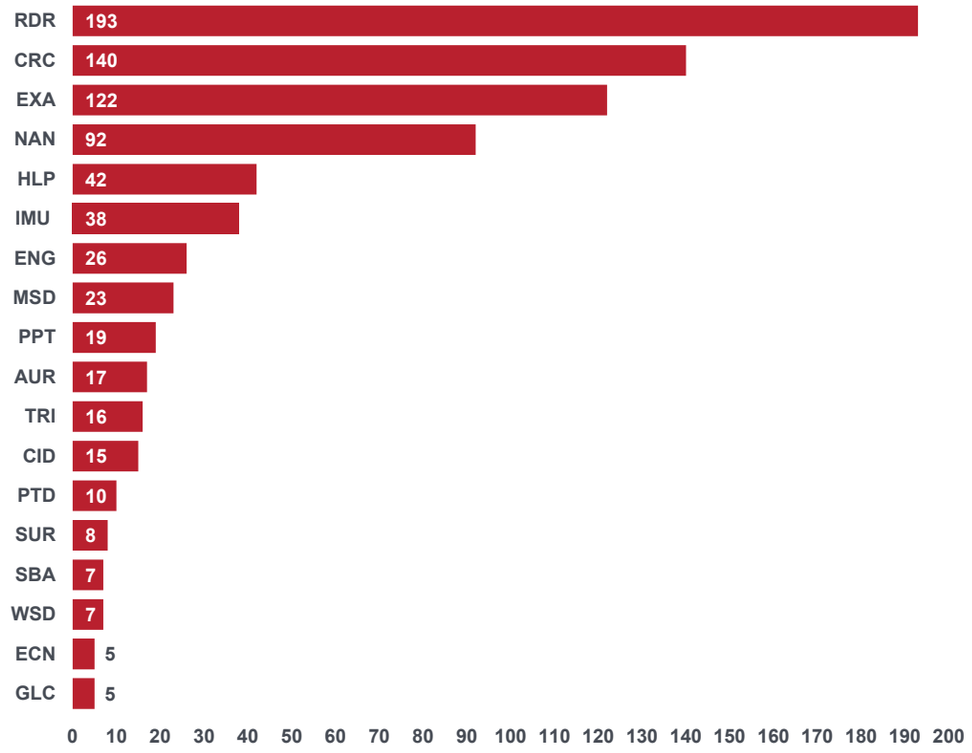


Table 13 shows the number and type of publications during the decade that were attributed to the MNF Sector. Publications were identified in the NIOSHTIC-2 database of occupational safety and health publications, documents, grant reports, and other communication products supported in whole or in part by NIOSH funding. Publication counts likely underestimate publications produced by the program during NORA's second decade due to the limitations of the data-collection methods available. Not all publications a program develops are included in the NIOSHTIC-2 database, and not all publications in the database can be associated with a specific program. During the second decade, 1,739 publications were attributed to the MNF Sector Program, with 1,391 of those intramural publications, and 419 extramural publications.

HAND-ARM VIBRATION

A NIOSH study on hand-arm vibration syndrome contributed scientific information to the revisions of national standards by the American National Standards Institute and the International Organization for Standardization.

ASSESSING BERYLLIUM

A NIOSH method, validated by other laboratories, provides industrial hygienists with a tool to assess exposure to beryllium oxide.

ARM DISORDER STUDY

A NIOSH study on work-related arm disorders contributed to WorkSafe British Columbia's new policy on musculoskeletal disorders (#27.00-27.40).

BERYLLIUM PROTECTION

NIOSH research with Brush Wellman Inc. to protect workers from exposure to beryllium led to the company implementing a comprehensive exposure-prevention program.

Table 13. Publications attributed to manufacturing by type (FY2007 through FY2014)

Publication Category	Total Number Publications	Intramural Publications	Extramural Publications
Journal article	1,025	773	299
Numbered publication or field study report	129	129	0
Abstract or conference proceeding	424	355	91
Book or book chapter	82	76	6
Newsletter, trade, or lay publication	25	25	1
Other	54	33	22
Totals	1,739	1,391	419

Note: The sum of intramural and extramural publications may exceed the total. A publication with intramural and extramural authors is counted in both categories.

Effectiveness

One measure of research effectiveness is the degree to which research activities addressed strategic goals of the MNF Program. Information on the sector goals addressed by a project is available for some NIOSH research projects. Table 14 shows how many projects addressed each strategic goal during the decade. The most-frequently addressed strategic goal (SG) was SG 05 (Respiratory Conditions and Diseases). SG 10 (Reduce Catastrophic Incidents), SG 07 (Vulnerable Populations), and SG 02 (Falls) were the least-frequently addressed strategic goals. Intramural research projects most-frequently addressed SG 05, followed by SG 09 (Build Knowledge Base), and SG 06 (Cancer Due to Exposure). Extramural projects most-frequently addressed SG 09, followed by SG 06, SG 05, and SG 04 (Reduce Hearing Loss).

Table 14. Number of manufacturing research projects by strategic goal (FY2007 through FY2014)

Strategic Goal (SG)	Intramural Projects	Extramural Projects	Total Number Projects
SG 01: Contact with objects	12	1	13
SG 02: Falls	3	1	4
SG 03: Reduce musculoskeletal disorders	29	9	38
SG 04: Reduce hearing loss	33	9	42
SG 05: Respiratory conditions and diseases	124	13	137
SG 06: Cancer due to exposures	65	17	82
SG 07: Vulnerable populations	8	0	8
SG 08: Small businesses	26	0	26
SG 09: Build knowledge base	113	19	132
SG 10: Reduce catastrophic incidents	4	0	4

*Data show how many research projects contributed 50% or more effort to the sector goal. Projects can address multiple goals.

Outcomes and Impact

Citation of NIOSH-funded journal articles is one measure of research impact. This indicates that scientists outside of NIOSH have used the institute's research outputs. Table 15 shows journal articles associated with the MNF sector and their citation numbers available in the Scopus citation database as of September 2016. Data are shown for publications resulting from intramural and extramural research. Table 15 lists fewer journal articles than the total number noted in the publication table for this program. Not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Table 15. Number of citations for manufacturing (FY2007 through FY2014)

Sector	Total
Total number of journal articles	924
Total number of citations	24,788
Intramural journal articles	684
Intramural citations	20,796
Extramural journal articles	285
Extramural citations	6,589

Note: Journal article counts included in this table are lower than the total number noted in the outputs table, because not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Another important measure of research outcomes is how many outputs others have obtained. Table 16 shows how many NIOSH-numbered publications associated with the MNF sector have been requested in printed form or downloaded electronically during NORA's second decade.

Table 16. Electronic and printed distribution of NIOSH-numbered manufacturing publications (FY2007 through FY2014)

Sector	Number of Publications	Electronic Downloads	Printed Distribution
Manufacturing	70	176,235	117,472

CONTROL BANDING

A NIOSH publication on a technique, known as control banding, that manages workplace risks was the basis of the American Industrial Hygiene Association's 5-year strategic plan, which identifies control banding as a top priority.

AIR FORCE REVIEW

NIOSH work, in part, led to the U.S. Air Force commissioning a National Academies review of beryllium.

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MINING


Photo by Thinkstock

The Mining Sector (MIN) comprises establishments that conduct or support coal mining, metal ore mining, and nonmetallic mineral mining and quarrying. Mining, as a basic industry, provides the foundation for our nation's economy, national defense, and standard of living. Workers in the MIN sector face risks that include falling materials, occupational hearing loss, explosions, fires, powered haulage, overexertion, electrical equipment, and exposure to particulates and dusts that include diesel emissions, coal dust, and silica dust.

The Mining Program's active participation from government, academia, labor, and industry helps guide intramural and extramural research activities. The Mining Safety and Health Research Advisory Committee (MSHRAC) advises the mining program's intramural research and extramural efforts via the authorities of the MINER Act. The committee, which convenes face-to-face at least once a year, has nine current and past members. The NORA Mining Sector Council was established in 2010. It has 27 members, 22 corresponding members, and 14 past members. The NORA Mining Sector Council meets annually at a place and time corresponding to the Society for Mining, Metallurgy, and Exploration (SME) annual meeting and exhibit. Teleconferences or web meetings occur throughout the year depending on the council's requirements. Both the MSHRAC and the NORA Mining Sector Council comprise committee members who represent a mix of government, academia, industry, and labor.

Underground Mine Communications Systems Improved through Research

Underground coal-mining disasters often kill miners. Fires, explosions, and falling rocks can sever communication with possible survivors by destroying wires that run through tunnels. This complicates rescue attempts. The Mine Improvement and New Emergency Response Act (MINER Act) (Public Law 109-236) of 2006 required mines to have wireless communications and electronic tracking systems. Even though we can send a signal far into space, signaling a mile underground is difficult. At the time, available products and technologies had severe limitations. NIOSH conducted needed research to allow quick installation of workable systems. NIOSH funded companies and universities with the expertise to conduct research and develop improved systems.

More than a third (35%) of underground coal-mining companies that installed systems in the United States selected one of the NIOSH-developed communication systems. NIOSH research helped to develop and enhance improved technologies. All underground coal mines now have a primary and secondary communication system installed. Those technologies are now in place to help survivors be rescued during mine disasters.

Details: Mining Topic: Emergency Communications and Tracking

OLDER MINER SAFETY

A NIOSH training resource led to mining companies implementing accommodations to reduce hazards for older miners.

RULE PROTECTS MINERS

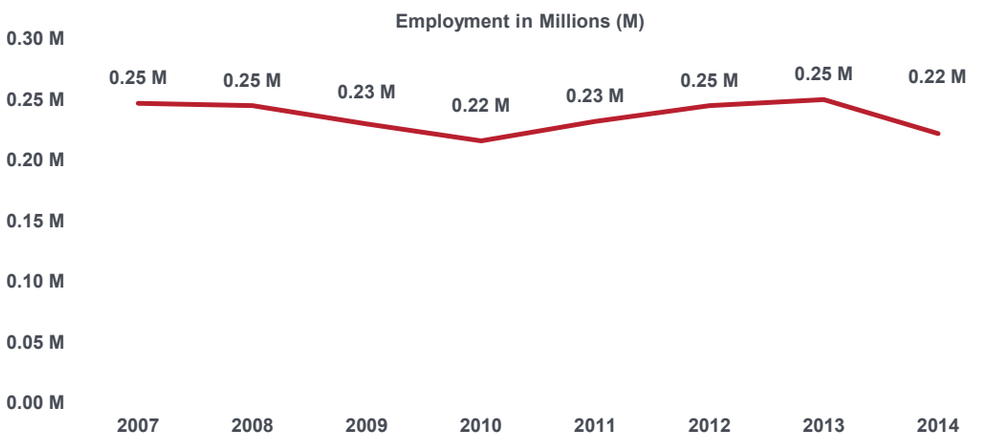
NIOSH research to protect workers from coal mine dust significantly contributed to a final rule from the Mine Safety and Health Administration.

Trends in Mining Employment, Fatalities, Injuries, and Illnesses

To provide context for the review of MIN activities, effectiveness, and impact during the decade, background rates for employment in the sector, fatalities, and nonfatal injuries are provided. From 2007 through 2014, employment in the MIN sector remained fairly stable (Figure 21). Employment data were collected from the Current Population Survey and include private industry and government (federal, state, and local) and the self-employed. Employment counts do not include volunteers.

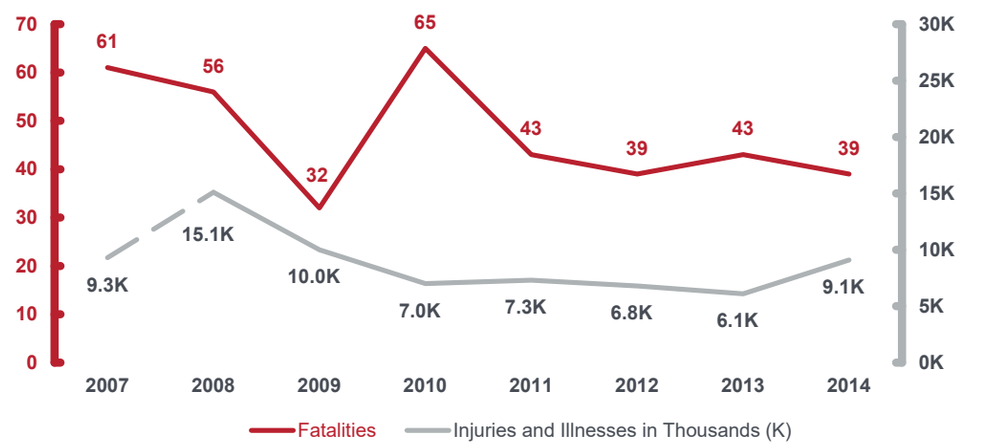
Fatalities generally declined during the decade, with a peak in 2010 (Figure 22). Nonfatal injuries (Figure 22) started the decade with a peak of 15,100 nonfatal injuries and illnesses in 2008 and reached a low of 6,100 injuries and illnesses in 2013 before rising again to 9,100 in 2014. Fatality and injury data were collected from the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Injuries and Illnesses (SOII). The latter does not include self-employed, and only private industry data were available before 2008.

Figure 21. Employment trend in mining (2007 to 2014)



Employment data: Bureau of Labor Statistics, Current Population Survey (CPS).

Figure 22. Fatality, injury or illness trends in mining (2007 through 2014)



Fatality data: Bureau of Labor Statistics, Census of Fatal Occupational Injuries (CFOI). Injury or illness data: Bureau of Labor Statistics, Survey of Occupational Injuries and Illnesses (SOII).

Activities and Output

Figure 23 shows how many research projects (intramural and extramural) contributed effort to the MIN Sector Program during the decade. Project counts reflect the percentage of total effort directly attributable to MIN Sector Program research. Example: If one project is attributed as 50% effort in MIN, then it is counted as 0.50 of a project.

Figure 23. Number of mining research projects (FY2007 through FY2015)

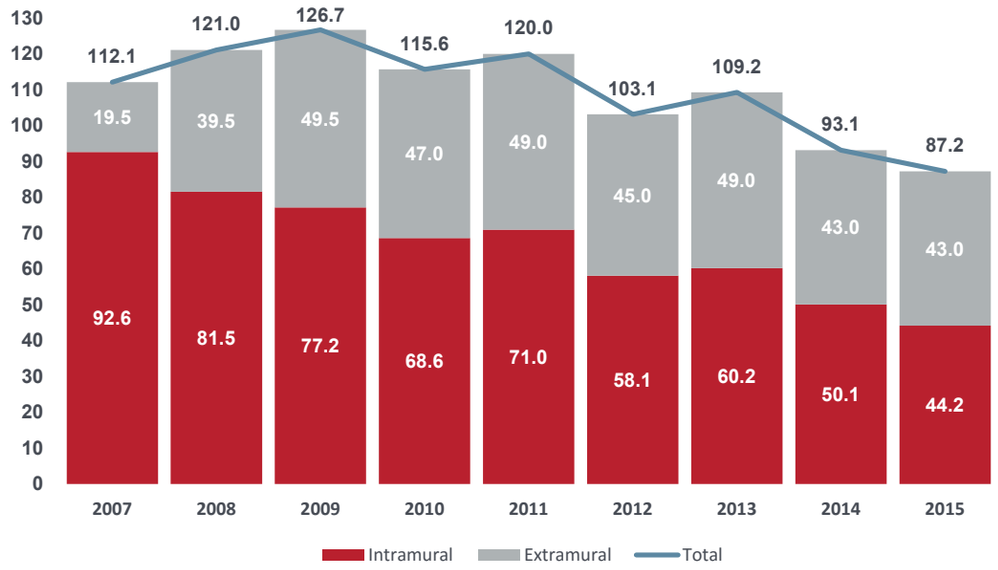
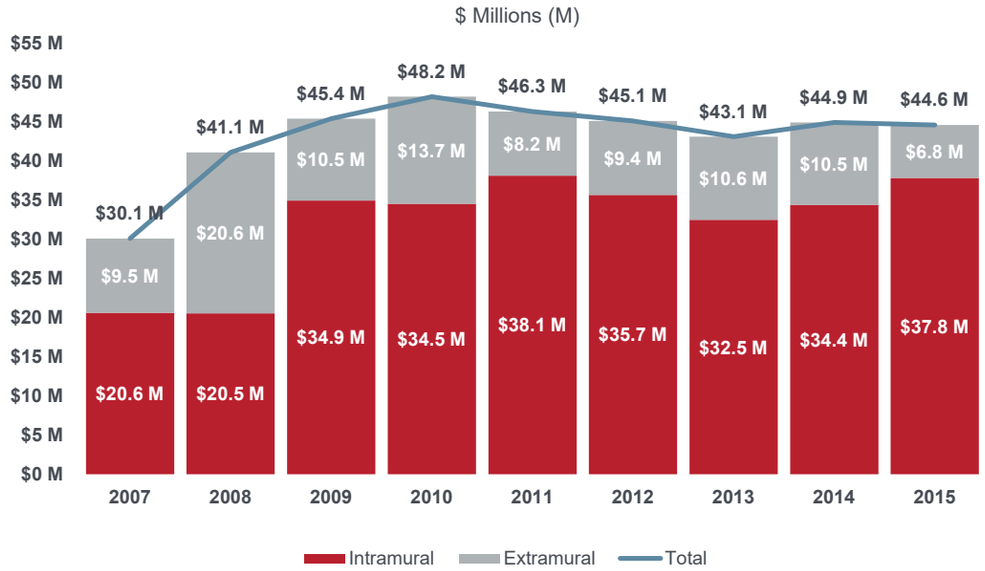


Figure 24 shows the funds invested in intramural and extramural research projects from 2007 through 2015. Investment totals reflect the percentage of total effort directly attributable to MIN Sector Program research goals. Example: If one project with a total budget of $100,000 is attributed as 50% effort in MIN, then the total investment is shown as $50,000. Totals in Figure 24 are shown in millions of dollars. Supplemental MINER Act funding is included in the intramural totals.

Figure 24. NIOSH investment in mining research projects (FY2007 through FY2015)



DIESEL-EMISSIONS CONTROL

NIOSH diesel-emissions control strategies and technologies have been widely implemented by U.S. underground mining companies.

DIESEL PARTICULATES

After NIOSH-developed a real-time instrument for measuring diesel engine particulates in an effort to reduce metal and nonmetal mining workers' exposures, companies began using it to analyze working conditions and improve exposure control.

ROCK BLASTING SAFETY

NIOSH work led to a mining stakeholder implementing the Institute's buffer design, which increases safety when rock blasting.

REDUCING COAL DUSTS

NIOSH work led to the Mine Safety and Health Administration's updated policy on specific methods, including scrubber use and deep cutting, to reduce airborne coal mine dust during the mining process known as continuous mining.

MACHINE ENCLOSURE

NIOSH and public sector mining partners created the Collapsible Drill Steel Enclosure, which absorbs sound to reduce roof-bolting machine noise, reduces time-weighted noise exposures during 8-hour work shifts, and reduces the potential for noise-induced hearing loss for miners.

Information on research associated with the cross-sector programs is available for FY2007 through FY2014. The cross-sector programs are described later in this supplement. The graph below shows the MIN research by cross-sector. A research project is counted if at least 50% of project activity is attributed to the MIN Sector Program and the corresponding cross-sector program. Cross-sector data are shown for five projects or more during the decade.

Figure 25. Number of projects by NIOSH cross-sector program for mining (FY2007 through FY2014)

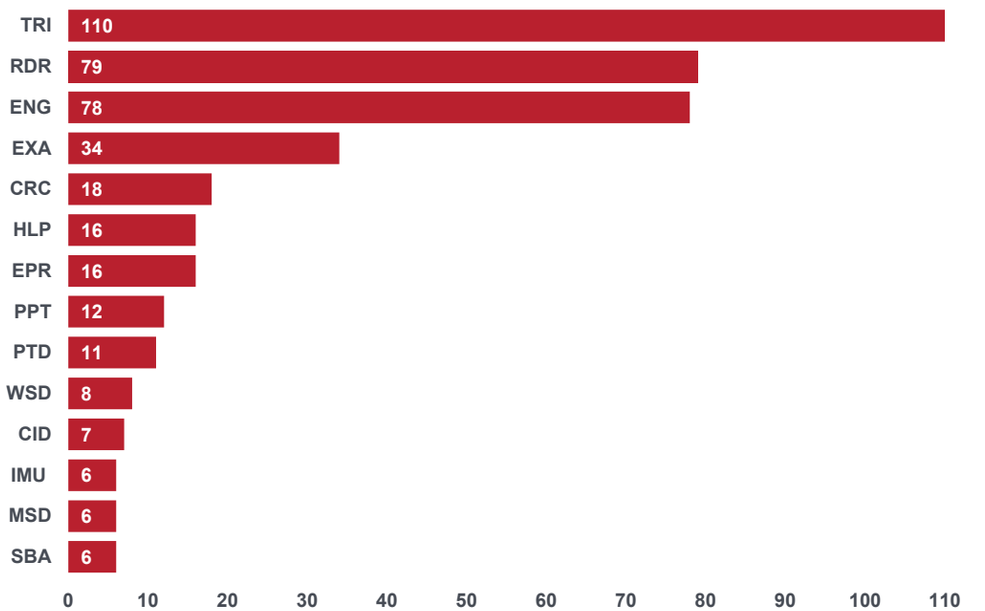


Table 17 shows the number and type of publications during the decade that were attributed to the MIN Sector Program. Publications were identified in the NIOSHTIC-2 database of occupational safety and health publications, documents, grant reports, and other communication products supported in whole or in part by NIOSH funding. Publication counts likely underestimate publications produced by the program during NORA's second decade due to the limitations of the data-collection methods available. Not all publications a program develops are included in the NIOSHTIC-2 database, and not all publications in the database can be associated with a specific program. During the second decade, 1,022 publications were attributed to the MIN Sector Program, with the intramural publication count (999) being significantly greater than extramural (31).

Table 17. Publications attributed to mining by type (FY2007 through FY2014)

Publication Category	Total Number Publications	Intramural Publications	Extramural Publications
Journal article	399	385	21
Numbered-publication or field study report	154	154	0
Abstract or conference proceeding	383	381	3
Book or book chapter	25	25	0
Newsletter, trade, or lay publication	33	33	0
Other	28*	21	7*
Totals	1,022	999	31

Note: The sum of intramural and extramural publications may exceed the total. A publication with intramural and extramural authors is counted in both categories.

*Table 17 does not include 158 publications resulting from the MINER Act contracts and grants program, including 94 contract reports, 27 PhD and 37 Masters dissertations.

Effectiveness

One measure of research effectiveness is how well research activities addressed strategic goals of the MIN Program. Information on the sector goals addressed by a project is available for some NIOSH research projects. Table 18 shows how many projects addressed each strategic goal during the decade. The most-frequently addressed strategic goal (SG) was SG 05 (Mine Disasters). SG 03 (Risk of Musculoskeletal Disorders) was the least-frequently addressed strategic goal. Intramural research projects most-frequently addressed SG 05, followed by SG 01 (Airborne contaminants) and SG 07 (Effective Interventions). Extramural projects most-frequently addressed SG 05, followed by SG 01 and SG 07.

Table 18. Number of mining research projects by strategic goal (FY2007 through FY2014)

Strategic Goal (SG)	Intramural Projects	Extramural Projects	Total Number of Projects
SG 01: Airborne contaminants	45	9	54
SG 02: Reduce hearing loss	16	3	19
SG 03: Risk of musculoskeletal disorders	11	0	11
SG 04: Reduce traumatic injuries	25	6	31
SG 05: Mine disasters	52	13	65
SG 06: Ground failures	26	6	32
SG 07: EffectiveiInterventions	38	9	47

Data shows how many research projects contributed 50% or more effort to the sector goal. Projects can address multiple goals.

SILICA HANDBOOK

NIOSH and the Industrial Minerals Association–North America developed a handbook for reducing miners' silica exposures.

DIESEL EXHAUST STUDY

A NIOSH study on reducing diesel exhaust and particulate matter emitted by mining equipment led to a new 2013 document, "Hazard Alerts for Diesel Exhaust/Diesel Particulate Matter," from the Mine Safety and Health Administration and the Occupational Safety and Health Administration.

MINE VENTILATION CHECKS

NIOSH research to improve mine safety led to industry using three different methods to check mine ventilation, well test analyses, and protocol development.

LED CAP LAMP

NIOSH research and development of an LED Cap Lamp led to the International Electrotechnical Commission updating its standards to ensure that future cap lamps provide greater visibility and safety for miners.

Outcomes and Impact

Citation of NIOSH-funded journal articles is one measure of research impact. This indicates that scientists outside of NIOSH have used the institute's research outputs. Table 19 shows journal articles associated with the MIN sector and their citation counts available in the Scopus citation database as of September 2016. Data are shown for publications resulting from intramural and extramural research. Journal article counts included in this table are lower than the total number noted in the publication table for this program. Not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Table 19. Number of citations for mining (FY2007 through FY2014)

Types of Citations	Total
Total number of journal articles	311
Total number of citations	3,739
Intramural journal articles	297
Intramural citations	3,557
Extramural journal articles	21
Extramural citations	263

Note: Journal article counts included in this table are lower than the total number noted in the outputs table, because not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Another important measure of research outcomes is how many outputs others have obtained. Table 20 shows how many NIOSH-numbered publications associated with the MIN sector have been requested in printed form or downloaded electronically during NORA's second decade.

Table 20. Electronic and printed distribution of NIOSH-numbered mining publications (FY2007 through FY2014)

Sector	Number of Publications	Electronic Downloads	Printed Distribution
Mining	150	66,227	62,194

The mining program has made significant progress on several priority research areas. Occupational exposure to airborne contaminants has been a major health concern for mine workers. The personal dust monitor was developed by NIOSH through intramural and extramural research efforts over the past decade. Real-time monitoring of respirable dust exposures enables mine operators to identify potential overexposures and to implement interventions to prevent these overexposures. Extensive NIOSH research has demonstrated personal dust monitor accuracy, and it has been specified by the Mine Safety and Health Administration (MSHA) for compliance dust sampling in respirable dust regulations.

After NIOSH research revealed that there are finer coal particles in intake airways, MSHA revised the Title 30 Code of Federal Regulations 75.403 for maintenance of incombustible content of rock dust. It increased the incombustible requirement [MSHA 2010] from 65% to 80% in intake airways. This work has also led to recommendations on rock-dusting definitions and practices (such as particle size, non-caking dust) used by the industry. In addition, NIOSH developed the Coal Dust Explosibility Meter (CDEM) to accurately predict the explosibility of samples of coal and rock dust mixtures in real time.

Over the past 10 years, mining program illumination research has resulted in new knowledge, methods, and lighting interventions that are revolutionizing mine illumination. More importantly, this research reduces the likelihood of fatalities and injuries caused by poor illumination that reduces the ability of miners to see hazards. This research has produced a light-emitting diode (LED) cap lamp that enables a 94% improvement for detecting slip, trip, and fall hazards and a 79.5% improvement in peripheral motion detection. The cap lamp research has directly impacted the Mine Safety and Health Administration's certification and regulatory procedures for field inspection of mine lighting, the International Electrotechnical Commission (IEC) Standard for cap lamps, and two commercial cap lamp designs.

Finally, eliminating fatalities and injuries from ground failure and machine-human interaction has been a major mine program initiative over the past 10 years. Many practical ground-control techniques have been developed through program research involving case histories of underground mines and large-scale laboratory testing of roof support elements. An entire toolbox of computer programs based on this research is available to assist the mining community with ground-control monitoring and design. To combat machine-related injuries and fatalities, the mining program developed and evaluated several proximity detection systems that establish safety zones around underground mining equipment. Incorporating NIOSH research findings, MSHA recently announced a proposed rule requiring mobile equipment to use this technology, and a final rule has been enacted to require all continuous mining machines be equipped with proximity detection systems.

BETTER DUST PRACTICES

A NIOSH device that better predicts the risk of coal dust explosion from coal mine dust samples led to improved safety for coal miners. The Mine Safety and Health Administration increased the fireproof requirement for rock dust in mine-intake airways, and rock-dust manufacturers, suppliers, and mine operators made changes to ensure that the rock dust used to prevent explosions meets size specifications.

MINE GAS SAFETY SYSTEM

Coal mining companies have embraced an in-mine nitrogen gas generation system that a commercial seller of gas generation equipment developed with NIOSH funding.

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OIL AND GAS EXTRACTION


Photo by Thinkstock

NIOSH began a program of work in the Oil and Gas Extraction (MIO) Sector and formed a council in 2008—2 years into NORA's second decade. The MIO sector comprises establishments that explore for crude petroleum and natural gas; drill, complete, service and equip wells; and prepare oil and gas for shipment from the producing property. Workers in this sector face many occupational risks, such as motor vehicle crashes, contact with tools and equipment, fire and explosions, exposure to chemicals, and shift work.

Extramural partners participating in the NORA Oil and Gas Extraction Sector Council include representatives from the oil and gas exploration and production industry (such as operators, drillers, or well servicers), academic partners, OSHA regional and national representatives, participants in the National STEPS Network (an industry group focused on improving safety), trade associations, and occupational safety and health professionals. Intramurally, the NORA Oil and Gas Sector Council has had participation from NIOSH researchers in WSD, DART, the Center for Motor Vehicle Safety, and the NIOSH Small Business Assistance and Outreach cross-sector program.

Identification and Control of Silica Exposures During Hydraulic Fracturing

In field studies during hydraulic fracturing operations, NIOSH identified a previously unrecognized hazard—exposure to silica dust, technically known as respirable crystalline silica. Respirable crystalline silica exposure is associated with occupational risk for serious lung diseases, including silicosis and lung cancer. Hydraulic fracturing is a process that involves pumping water, sand, and chemicals into a rock formation under extreme pressure to enhance the recovery of crude oil and natural gas. NIOSH researchers determined that some workers regularly faced exposure to respirable crystalline silica (the primary component of frack sand) at concentrations many times the NIOSH-recommended exposure limit, and these emissions originated from sand-moving machinery. NIOSH disseminated these findings and recommendations widely, including in scientific and trade journals.

NIOSH conceived, developed, and field-tested an engineering control that is both low cost and effective—it can reduce silica emissions on sand-moving equipment by 99%. Industry responded positively and immediately to the NIOSH recommendations that stemmed from the field study. A national workgroup formed to enact the recommendations and promoted them throughout the industry. As a result, companies have spent millions of dollars redesigning their equipment to protect workers from respirable crystalline silica. Workers are now aware of respirable crystalline silica and of how to protect themselves when working around frack sand.

Details: Worker Exposure to Crystalline Silica During Hydraulic Fracturing and NIOSH-Designed Technology Can Reduce Workers' Exposure to Silica at Hydraulic Fracturing Sites

FRACKING AND SILICA

NIOSH findings of potential silica exposure during hydraulic fracturing (fracking) led to a joint workgroup between NIOSH and industry partners to develop ways to control this hazard.

HEARING LOSS STANDARD

NIOSH helped the National Health and Nutrition Examination Survey improve surveillance of work-related hearing loss, which contributed to a new ISO standard.

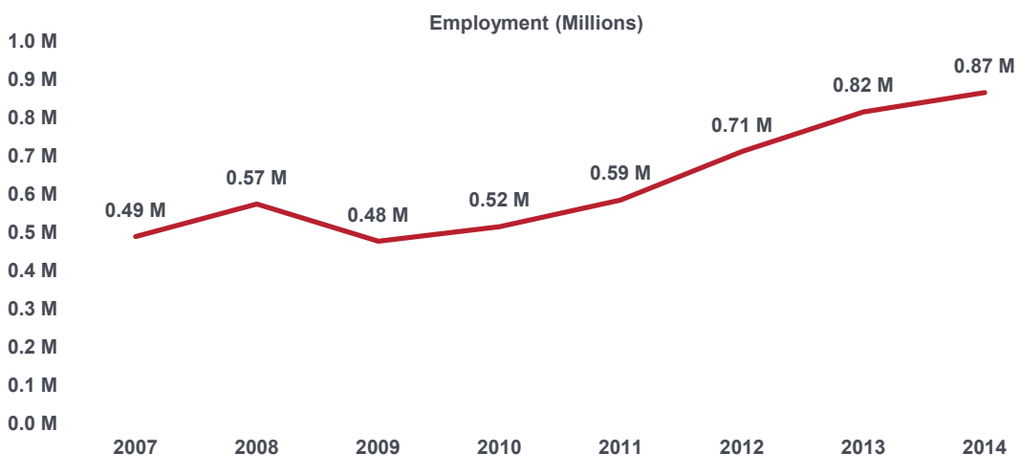
The NORA Oil and Gas Extraction Sector Council matured over the decade into a representative body that actively participates in shaping the research agenda for the nation. Because there is limited research on this topic nationally, it is important to maintain this council and focus the direction of research that does occur. The NIOSH Oil and Gas Sector Program hopes that the next decade will see workplace hazards and exposures reduced even more.

Trends in Oil and Gas Extraction Employment, Fatalities, Injuries, and Illnesses

To provide context for reviewing MIO activities, effectiveness, and impact during the decade, background rates for employment in the sector, fatalities, and nonfatal injuries are provided. From 2007 through 2014, employment in the MIO sector increased from almost 500,000 to 870,000 workers (Figure 26). Employment data were collected from the Current Population Survey and includes private industry and government (federal, state, and local) and the self-employed. Volunteers are not included in employment counts.

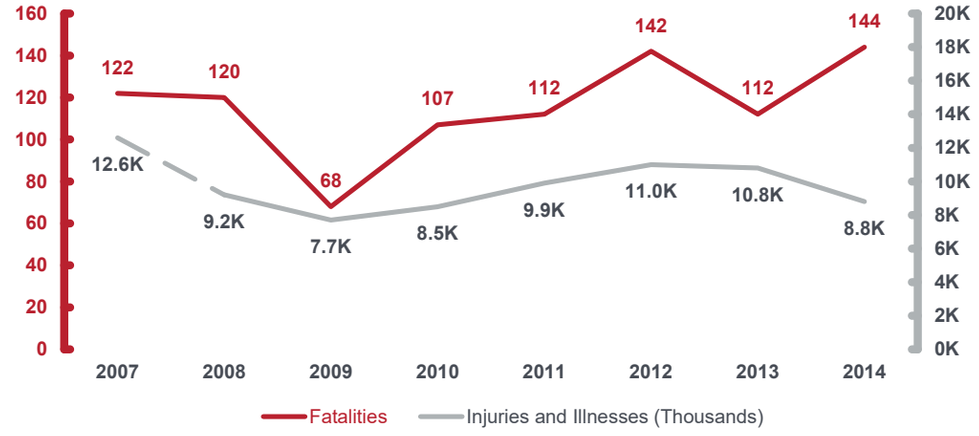
Fatalities in MIO dropped by 50% between 2007 (122 fatalities) and 2009 (68 fatalities), only to increase to a high of 144 in 2014 (Figure 27). Nonfatal injuries and illnesses declined from 12,600 in 2007 to 8,800 in 2014 (Figure 27). Fatality and injury data were collected from the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Injuries and Illnesses (SOII). The latter does not include self-employed, and only private industry data were available before 2008.

Figure 26. Employment trend in oil and gas extraction (2007 through 2014)



Employment data: Bureau of Labor Statistics, Current Population Survey (CPS).

Figure 27. Fatality, injury or illness trends in oil and gas extraction (2007 through 2014)

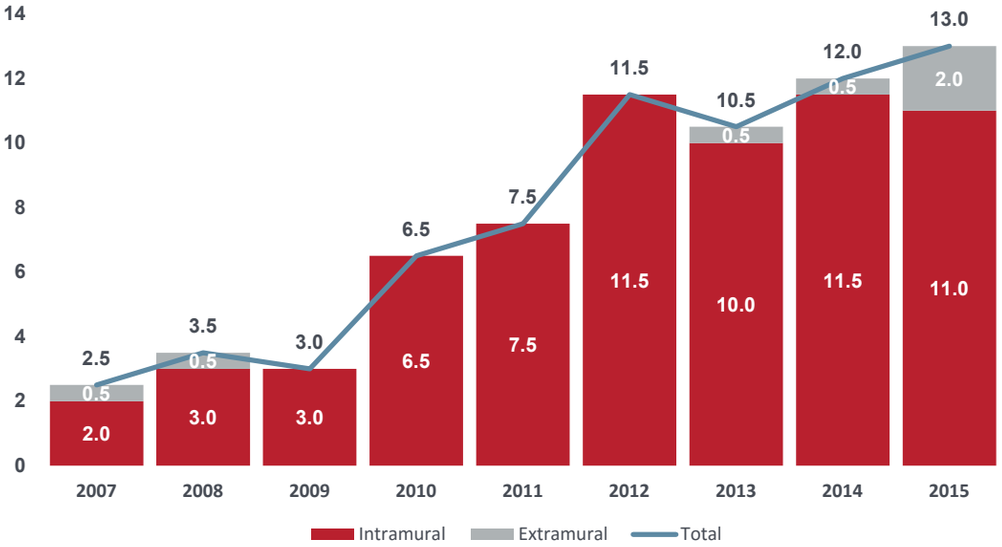


Fatality data: Bureau of Labor Statistics, Census of Fatal Occupational Injuries (CFOI). Injury or illness data: Bureau of Labor Statistics, Survey of Occupational Injuries and Illnesses (SOII).

Activities and Output

Figure 28 shows how many research projects (intramural and extramural) contributed effort to the MIO Sector Program during the decade. Project counts reflect the percentage of total effort directly attributable to MIO Sector Program research. Example: If one project is attributed as 50% effort in MIO, then it is counted as 0.50 of a project.

Figure 28. Number of oil and gas extraction research projects (FY2007 through FY2015)



MOTOR VEHICLE SAFETY

NIOSH and partners developed a guide for reducing motor vehicle fatalities that the International Oil and Gas Producers adopted.

ELIMINATING SILICOSIS

NIOSH and other organizations helped Chile establish its National Program to Eliminate Silicosis by starting a regional silica analytic laboratory, assessing silica-related risks in workplaces, and giving trainings in reading X-rays, testing lung function, and assessing workplace risks.

NEW AIRBORNE STANDARD

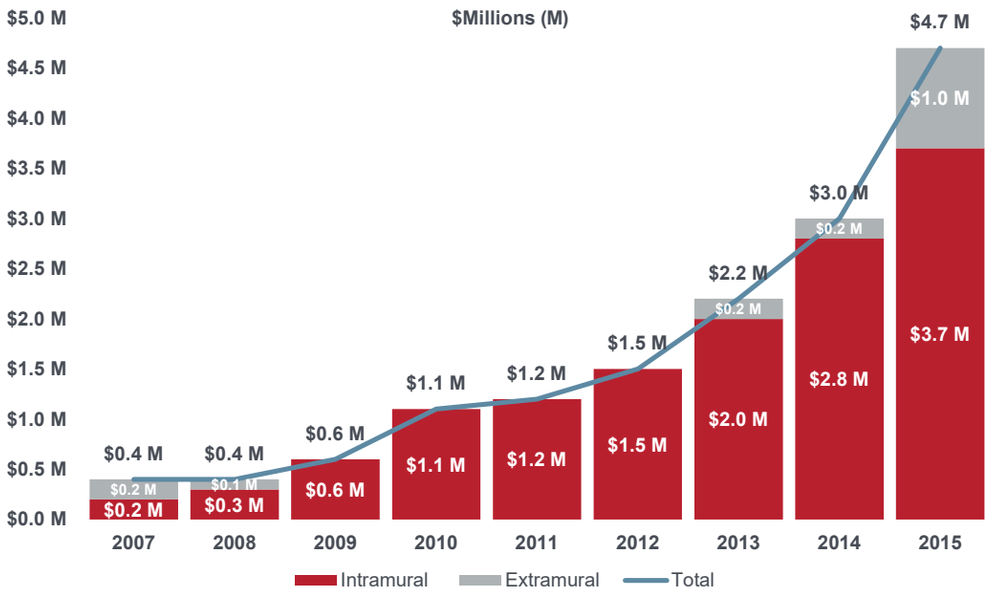
A NIOSH document, "Components for Direct Reading Instruments for Gases and Vapors," contributed to a new ISO standard to improve monitoring for dangerous airborne substances.

AIRBORNE TOXIC METALS

NIOSH work contributed to an American Society for Testing and Materials standard for using a technique, called ICP-MS, to measure toxic metals in airborne substances.

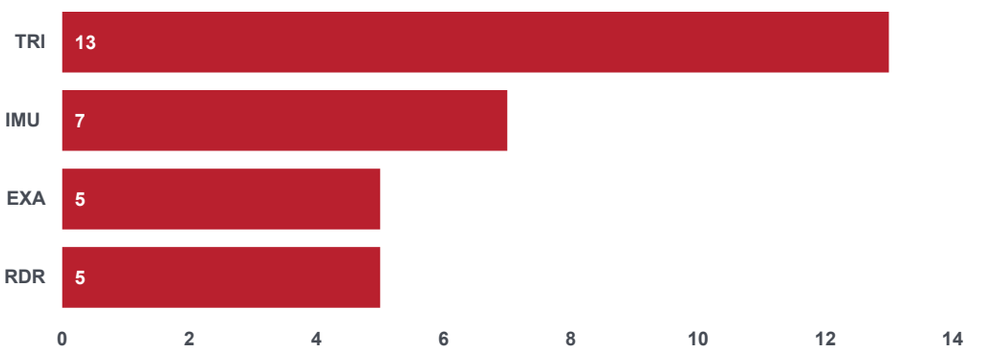
Figure 29 shows the funds invested in intramural and extramural research projects from 2007 through 2015. Investment totals reflect the percentage of total effort directly attributable to MIO Sector Program research goals. Example: If one project with a total budget of $100,000 is attributed as 50% effort in MIO, then the total investment is shown as $50,000. Totals in Figure 29 are shown in millions of dollars.

Figure 29. NIOSH investment in oil and gas extraction research projects (FY2007 through FY2015)



Information on research associated with the cross-sector programs is available for FY2007 through FY2014. The cross-sector programs are described later in this supplement. Figure 30 shows MIO research by cross-sector. A research project is counted if at least 50% of project activity is attributed to the MIO Sector Program and the corresponding cross-sector program. Cross-sector data are shown for five projects or more during the decade.

Figure 30. Number of projects by NIOSH cross-sector program for oil and gas extraction (FY2007 through FY2014)



PERSONAL DUST MONITOR

The NIOSH Personal Dust Monitor led to increased efforts to protect mine workers from coal-dust exposure. The Mine Safety and Health Administration's updated regulations specify the monitor's use for compliance dust sampling, and a private company commercialized the monitor.

Table 21 shows the number and type of publications during the decade that were attributed to the MIO sector. Publications were identified in the NIOSHTIC-2 database of occupational safety and health publications, documents, grant reports, and other communication products supported in whole or in part by NIOSH funding. Publication counts likely underestimate publications produced by the program during NORA's second decade due to the limitations of the data-collection methods available. Not all publications a program develops are included in the NIOSHTIC-2 database, and not all publications in the database can be associated with a specific program. During the second decade, 22 publications were attributed to the MIO Sector Program, with the intramural publication count (22) being significantly greater than extramural (0).

Table 21. Publications attributed to oil and gas extraction by type (FY2007 through FY2014)

Publication Category	Total Number Publications	Intramural Publications	Extramural Publications
Journal article	9	9	0
Numbered publication or field study report	5	5	0
Abstract or conference proceeding	5	5	0
Book or book chapter	2	2	0
Newsletter, trade, or lay publication	1	1	0
Other	0	0	0
Totals	22	22	0

Note: The sum of intramural and extramural publications may exceed the total. A publication with intramural and extramural authors is counted in both categories.

Effectiveness

One measure of research effectiveness is the degree to which research activities addressed strategic goals of the MIO Program. Information on the sector goals addressed by a project is available for some NIOSH research projects. Table 22 shows how many projects addressed each strategic goal during the decade. The two most-frequently addressed strategic goals (SG) were SG 06 (Chemical Exposures) and SG 01 (Transportation Related Injuries). SG 09 (Vulnerable Populations), which was retired after FY2012 and replaced with a new priority in FY2014, did not address any strategic goals. Only intramural research projects supported goals.

EXPOSURE CALCULATOR

A NIOSH web-based calculator is a tool that industrial hygienists use to estimate absorption after brief exposure to the skin of workplace chemicals.

MINE COMMUNICATIONS

Government, industry, and labor representatives collaborated to assess the challenges of improving underground mine communications and tracking technologies that are vital for locating and rescuing miners trapped after a mine cave-in. Systems developed through NIOSH funding and research account for a significant percentage of installed communications systems, and NIOSH funding of fundamental research stimulated the development of additional systems, which have also been accepted by the Mine Safety and Health Administration and installed by mining companies.

Table 22. Number of oil and gas extraction research projects by strategic goal (FY2007 through FY2014)

Strategic Goal (SG)	Intramural Projects	Extramural Projects	Total Number of Projects
SG 01: Transportation-related injuries	7	0	7
SG 02: Contact injuries	3	0	3
SG 03: Falls	6	0	6
SG 04: Fires and explosions	3	0	3
SG 05: Improvement in workplace practices, procedures and policies (Retired in FY2011)	2	0	2
SG 06: Chemical exposures	11	0	11
SG 07: Develop industry-specific products (Retired after FY2014)	5	0	5
SG 08: Nonfatal occupational injuries (Retired after FY2012)	1	0	1
SG 09: Surveillance (Retired after FY2012)	0	0	0
SG10: Oil spill response workers (Retired after FY2013)	1	0	1

Data shows how many research projects contributed 50% or more effort to the sector goal. Projects can address multiple goals.

Outcomes and Impact

Citation of NIOSH-funded journal articles is one measure of research impact. This indicates that scientists outside of NIOSH have used the institute's research outputs available in the Scopus citation database as of September 2016. In Table 23, data are shown for publications resulting from intramural and extramural research. Journal article counts included in Table 23 are lower than the total number noted in the publication table for this program. Not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Table 23. Number of citations for oil and gas extraction (FY2007 through FY2014)

Type of Citation	Total
Total number of journal articles	5
Total number of citations	83
Intramural journal articles	5
Intramural citations	83
Extramural journal articles	0
Extramural citations	0

Note: Journal article counts included in this table are lower than the total number noted in the outputs table, because not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

HEARING DEVICE RULE

NIOSH research with collaborators on hearing-protection devices contributed scientific information to a proposed rule by the U.S. Environmental Protection Agency.

Another important measure of research outcomes is how many outputs others have obtained. Table 24 shows how many NIOSH-numbered publications associated with the MIO sector have been requested in printed form or downloaded electronically during NORA's second decade.

Table 24. Electronic and printed distribution of NIOSH-numbered oil and gas extraction publications (FY2007 through FY2014)

Sector	Number of Publications	Electronic Downloads	Printed Distribution
Oil and Gas Extraction	5	14	645

The NORA Oil and Gas Extraction Sector Program has helped improve safety and health for workers. Here are three highlights:

1. Reduction in fatality rates—From 2003 through 2013, the fatality rate for oil and gas extraction workers in the United States decreased significantly (36%). Collaborative outputs and information shared through NORA likely contributed (such as safety videos, alerts, articles).

2. Prevention of respirable silica hazards—Members of the NIOSH Oil and Gas Extraction Sector Program identified overexposure of respirable silica to workers during hydraulic fracturing. Multiple outputs discussed findings, including peer-reviewed and trade journal articles, an OSHA-NIOSH Hazard Alert, and dozens of presentations. A new retrofit technology, the mini-baghouse assembly, is being developed and has undergone successful field testing. The National STEPS Network, a nationwide all-volunteer industry group, formed a special focus group with more than 100 members to share ways to reduce exposure. Major well-servicing companies have invested millions of dollars in redesigning their equipment to reduce respirable silica to levels well below the OSHA Permissible Exposure Limit.

3. Prevention of fatalities due to hydrocarbon gases and vapors—NORA sector council members and academic partners identified nine worker deaths from 2010 through 2014 that were likely due to exposure to hydrocarbon gases and vapors. A web special report and two NIOSH Science Blog articles were posted on this topic. In response, the National STEPS Network, OSHA, NIOSH, and others issued a hazard alert that was disseminated to tens of thousands of oilfield personnel. Regional alerts were also issued. Well Servicing Magazine wrote an article on the hazard. No fatalities were reported in 2015.

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PUBLIC SAFETY

The Public Safety (SPS) Sector was considered a sub-area of the NORA Services Sector for the first 3 years of the second decade. In 2009, NIOSH began a program of work in the SPS sector and formed a council. The SPS sector comprises establishments engaged in corrections, emergency medical services, fire services, wildland fire, and law enforcement.

The Public Safety Sector Program and council addresses critical workplace safety and health issues for the fire service, law enforcement, corrections, emergency medical service, and wildland fire fighting. The extramural partners on the sector council includes professional and union associations, academia, standards-development organizations, and state and federal agencies.

These NIOSH intramural organizations are represented on the sector council and steering committee:

- Division of Applied Research and Technology
- Division of Safety Research
- Division of Surveillance, Hazard Evaluations, and Field Studies
- Emergency Preparedness and Response Office
- National Personal Protective Technology Laboratory
- Office of the Director
- Respiratory Health Division
- Western States Division

Preventing Fire Fighter Deaths Through Investigations

About 1.1 million fire fighters risk their lives protecting the public in the United States. On average, 90 to 100 fire fighters die in the line of duty each year. To prevent future deaths, NIOSH independently investigates select fire fighter deaths under its Fire Fighter Fatality Investigation and Prevention Program (FFFIPP).

Based on these investigations, NIOSH found that self-contained breathing apparatus (SCBA) facepiece failures from high heat and flame exposure contributed to fire-fighter fatalities. NIOSH helped develop new test methods and performance criteria to prevent the type of failures that contributed to fire-fighter deaths.

NIOSH participation on the National Fire Protection Association (NFPA) Technical Committee on Respiratory Protection Equipment led to a revised standard to help protect fire fighters. Specifically, the NFPA revised its 1981 Standard on Open-Circuit Self-Contained Breathing Apparatus for Emergency Services.

Details: Fire Fighter Fatality Investigation and Prevention

NO-NOSE BIKE SEATS USED

NIOSH research that found fewer sexual and reproductive problems among patrol officers using no-nose bicycle seats compared with traditional seats led police departments in Seattle, WA; San Antonio, TX; Miami, FL; and Chicago, IL; to offer no-nose saddles as standard equipment for bicycle patrols.

BIKE OFFICER HEALTH

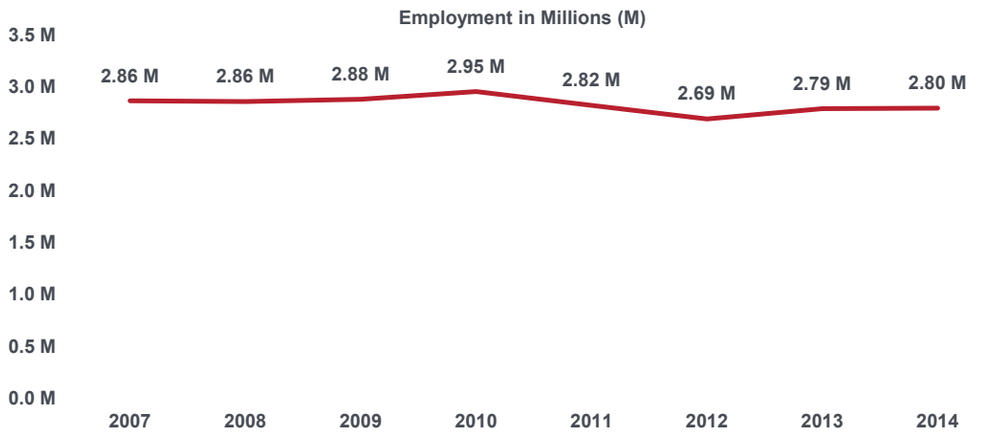
NIOSH worked with several police departments on a study that found fewer sexual and reproductive problems among patrol officers using no-nose bicycle seats compared to traditional seats. Based on these results, one police department ordered 400 no-nose seats for its patrol officers.

Trends in Public Safety Employment, Fatalities, Injuries, and Illnesses

Background rates for employment in the sector, fatalities, and nonfatal injuries give context for the decade review of the SPS activities, effectiveness, and impact. From 2007 through 2014, employment in the SPS sector remained fairly stable (Figure 31). Employment data were collected from the Current Population Survey and includes private industry and government (federal, state, and local) and the self-employed. Volunteers are not included in employment counts.

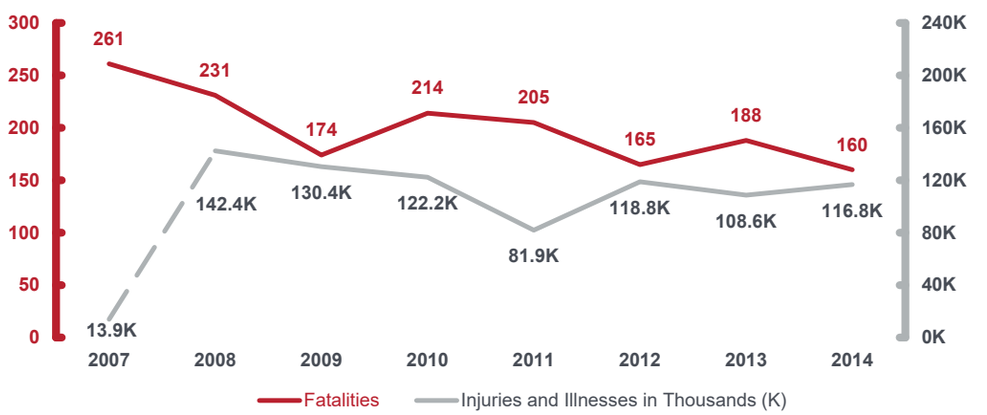
Fatalities declined between 2007 and 2009, from 261 to 174, with fatalities increasing slightly by 2010 before declining to a low of 160 in 2014 (Figure 32). Nonfatal injuries and illnesses (Figure 32) decreased between 2008 and 2011, reaching a low for the decade of nearly 82,000 incidences. The data then increased to more than 100,000 by 2012 and leveled off. Fatality and injury data were collected from the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Injuries and Illnesses (SOII). The latter does not include self-employed, and only private industry data were available before 2008.

Figure 31. Employment trend in public safety (2007 through 2014)



Employment data: Bureau of Labor Statistics, Current Population Survey (CPS).

Figure 32. Fatality, injury or illness trends in public safety (2007 through 2014)



Fatality data: Bureau of Labor Statistics, Census of Fatal Occupational Injuries (CFOI). Injury or illness data: Bureau of Labor Statistics, Survey of Occupational Injuries and Illnesses (SOII).

Activities and Output

Figure 33 shows how many research projects (intramural and extramural) contributed effort to the SPS Sector Program during the decade. Project counts reflect the percentage of total effort directly attributable to SPS Sector Program research. Example: If one project is attributed as 50% effort in SPS, then it is counted as 0.50 of a project.

Figure 33. Number of public safety research projects (FY2007 through FY2015)

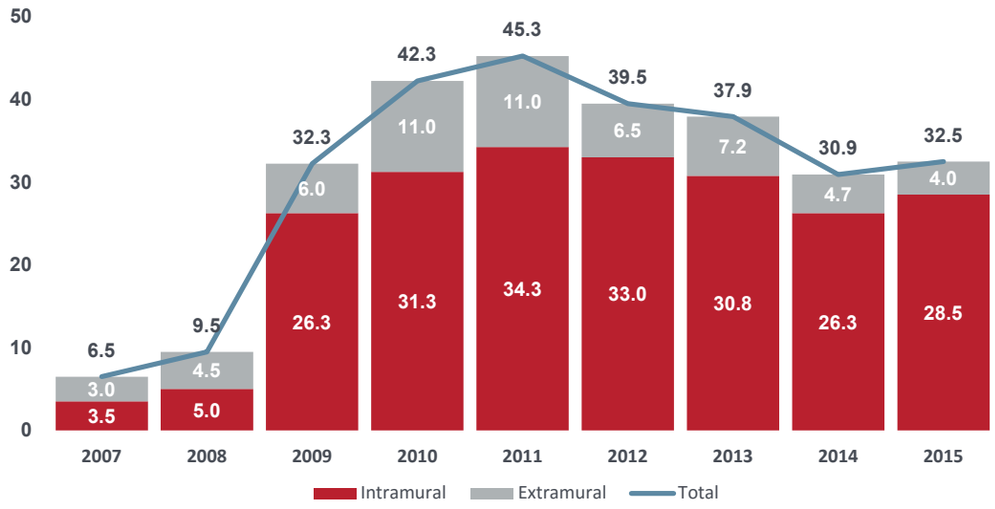
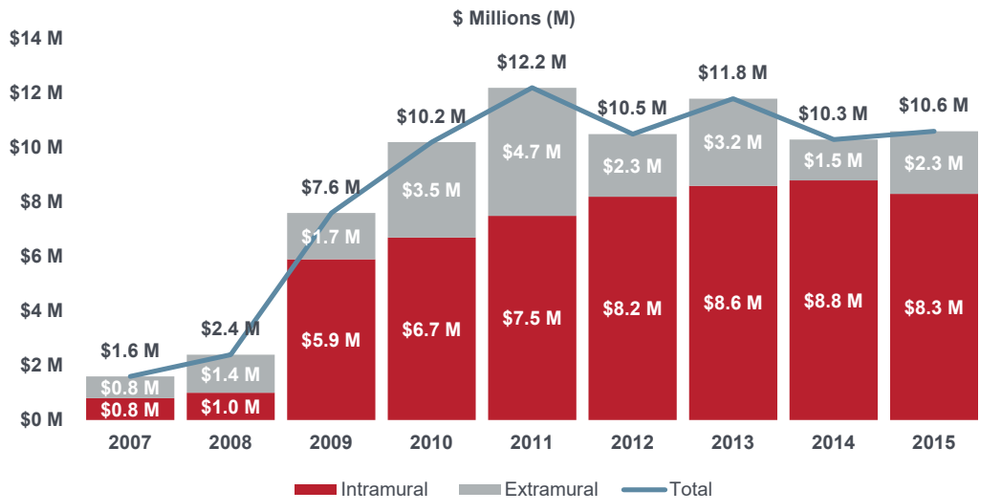


Figure 34 shows the funds invested in intramural and extramural research projects from 2007 through 2014. Investment totals reflect the percentage of total effort directly attributable to SPS Sector Program research goals. Example: If one project with a total budget of $100,000 is attributed as 50% effort in SPS, then the total investment is shown as $50,000. Totals in Figure 34 are shown in millions of dollars.

Figure 34. NIOSH investment in public safety research projects (FY2007 through FY2015)



OXYGEN SYSTEM TESTING

NIOSH investigations contributed to the Food and Drug Administration's proposed rule (72 FR 8643) that would require testing of portable medical oxygen-delivery systems to ensure the devices are not flammable.

STUDYING EMS CRASHES

A NIOSH pilot project led to the National Highway Traffic Safety Administration improving surveillance of emergency medical services crashes.

FIRE INVESTIGATIONS

NIOSH fire investigations contributed to increased fire fighter safety:

- NIOSH research contributed to National Fire Prevention Association updated standards in several areas of fire-fighter safety, including Structural Fire Fighting and Proximity Fire Fighting, Protective Clothing and Equipment, and Electronic Safety Equipment for Emergency Responders.
- NIOSH studies provided the methodology for a new American Society for Testing and Materials standard for preventing risk of fire fighters suffering burns from heat building up in their protective clothing.

TRAINING FOR POLICE

NIOSH created training materials for law enforcement agencies to reduce workplace violence and related injuries in the retail industry. Police agencies in at least five cities are already using the materials.

Information on research associated with the cross-sector programs is available for FY2007 through FY2014. The cross-sector programs are described later in this supplement. Figure 35 shows the SPS research by cross-sector. A research project is counted if at least 50% of project activity is attributed to the SPS Sector Program and the corresponding cross-sector program. Cross-sector data are shown for five projects or more during the decade.

Figure 35. Number of projects by NIOSH cross-sector program for public safety (FY2007 through FY2014)

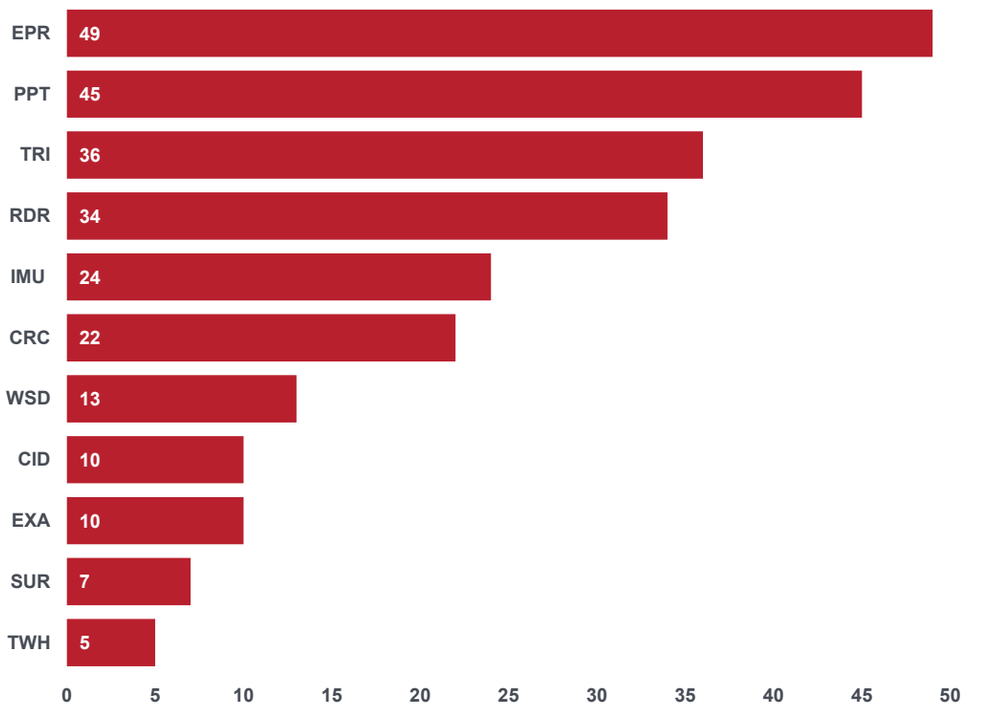


Table 25 shows the number and type of publications during the decade that were attributed to the SPS Sector. Publications were identified in the NIOSHTIC-2 database of occupational safety and health publications, documents, grant reports, and other communication products supported in whole or in part by NIOSH funding. Publication counts likely underestimate publications produced by the program during NORA's second decade due to the limitations of the data-collection methods available. Not all publications a program develops are included in the NIOSHTIC-2 database, and not all publications in the database can be associated with a specific program. During the second decade, 499 publications were attributed to the MIO Sector Program, with the intramural publication count (470) being significantly greater than extramural (35).

Table 25. Publications attributed to public safety by type (FY2007 through FY2014)

Publication Category	Total Number Publications	Intramural Publications	Extramural Publications
Journal article	124	100	30
Numbered publication or field study report	314	314	0
Abstract or conference proceeding	40	37	3
Book or book chapter	6	6	0
Newsletter, trade, or lay publication	0	0	0
Other	12	10	2
Totals	499	470	35

Note: The sum of intramural and extramural publications may exceed the total. A publication with intramural and extramural authors is counted in both categories.

Effectiveness

One measure of research effectiveness is the degree to which research activities addressed strategic goals of the SPS Program. Information on the sector goals addressed by a project is available some NIOSH research projects. Table 26 shows how many projects addressed each strategic goal during the decade. The most-frequently addressed strategic goal (SG) was SG 01 (Chronic and Acute Disease Among Fire fighters). SG 04 (Musculoskeletal Disorders in Firefighting), SG 11 (Occupational Stressors in Corrections), and SG 12 (Vehicle-Related Injury Among EMS) were the least-frequently addressed strategic goals. Intramural research projects most-frequently addressed SG 01, followed by SG 14 (EMS Exposure Hazards) and SG 02 (Structural Firefighting). Extramural projects most-frequently addressed SG 02, followed by SG 01.

Table 26. Number of public safety research projects by strategic goal (FY2007 through FY2014)

Strategic Goal (SG)	Intramural Projects	Extramural Projects	Total Number of Projects
SG 01: Chronic and acute disease among fire fighters	46	5	51
SG 02: Structural firefighting	21	7	28
SG 03: Vehicle-related injury in firefighting	8	2	10
SG 04: Musculoskeletal disorders in firefighting	3	0	3
SG 05: Surveillance in law enforcement	16	4	20
SG 06: Vehicle-related injury in law enforcement	6	0	6
SG 07: Criminal assaults in law enforcement (Retired after FY2012)	3	1	4
SG 08: CVD in law enforcement	9	2	11

(Continued)

HEAT BUILD-UP STANDARD

NIOSH studies provided the methodology for a new American Society for Testing and Materials standard for preventing risk of fire fighters suffering burns from heat building up in their protective clothing.

RESPIRATORY PROTECTION

NIOSH findings contributed to the Occupational Safety and Health Administration reforming its respiratory protection standard.

AMBULANCE DESIGN

NIOSH research contributed to new standards and improved ambulance design to protect emergency medical workers.

DETECTING METH RESIDUE

NIOSH worked with the state health departments in Cincinnati and Colorado, as well as SKC, Inc.; the National Jewish Medical and Research Center; and Colorado law enforcement agencies, to develop a method to detect methamphetamine residues and toxins contaminating surfaces often found in the labs during and after cleanup. A company successfully licensed and commercialized the product for release to first responders and other agencies.

Table 26 (Continued). Number of public safety research projects by strategic goal (FY2007 through FY2014)

Strategic Goal (SG)	Intramural Projects	Extramural Projects	Total Number of Projects
SG 09: Injury in corrections	3	1	4
SG10: Infectious diseases in corrections	8	1	9
SG 11: Occupational stressors in corrections	2	1	3
SG12: Vehicle-related injury among EMS	3	0	3
SG 13: Patient transfer injuries in EMS	2	2	4
SG 14: EMS exposure hazards	27	3	30
SG15: EMS work policies	4	2	6
SG16: EMS health and safety surveillance	5	1	6
SG 17: Illness and injuries in wildland firefighting (Retired after FY2014)	2	2	4

Data shows how many research projects contributed 50% or more effort to the sector goal. Projects can address multiple goals.

Outcomes and Impact

Citation of NIOSH-funded journal articles is one measure of research impact. This indicates that scientists outside of NIOSH have used the institute's research outputs. Table 27 shows journal articles associated with the SPS sector and their citation counts available in the Scopus citation database as of September 2016. Data are shown for publications resulting from intramural and extramural research. Journal article counts included in this table are lower than the total number noted in the publication table for this program. Not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Table 27. Number of citations for public safety (FY2007 through FY2014)

Type of Citation	Total
Total number of journal articles	106
Total number of citations	991
Intramural journal articles	82
Intramural citations	720
Extramural journal articles	29
Extramural citations	316

Note: Journal article counts included in this table are lower than the total number noted in the outputs table, because not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Another important measure of research outcomes is how many outputs others have obtained. Table 28 shows how many NIOSH-numbered publications associated with the SPS sector have been requested in printed form or downloaded electronically during NORA's second decade.

Table 28. Electronic and printed distribution of NIOSH-numbered public safety publications (FY2007 through FY2014)

Sector	Number of Publications	Electronic Downloads	Printed Distribution
Public Safety	65	180,434	367,301

Additional sector outcomes during the decade are described below.

Study of Cancer among U.S. Fire Fighters—In 2010, NIOSH researchers launched a multi-year study to examine whether fire fighters have a higher risk of cancer and other causes of death due to job exposures. The project has yielded newsletters, journal articles, presentations, and educational materials and is impacting changes in fire department policies, practices, and procedures.

Partnering with Industry to Build Safe EMS Work Environments—Objectives include reducing fatalities and severity of injuries for workers and patients in a moving ambulance. Outcomes include incorporating new crash-test methods into national bumper-to-bumper ambulance standards and manufacturing of crashworthy designs and components into vehicles.

SHIELD (Safety and Health Improvement Enhancing Law Enforcement Departments)—Objectives include reducing health and safety risks to law enforcement officers through healthy lifestyle behaviors, including improved diet, fitness, sleep, weight, stress management, resiliency, and reduced impacts from tobacco and alcohol use.

Fire Fighter Fatality Investigation and Prevention Program (FFFIPP)—Six fatality case investigations found that self-contained breathing apparatus (SCBA) facepiece lenses had melted, allowing direct respiratory system exposure to heat and toxic gases. NFPA was notified of these findings and conclusions. This resulted in research and testing that led to developing new test methods and performance criteria for lens radiant heat resistance performance and elevated temperature and flame resistance performance, incorporated into the NFPA 1981 SCBA Standard.

CBRN Respirator Certification—NIOSH increased the inventory of respirators to enhance Public Safety Worker protection by certifying 130 chemical, biological, radiological and nuclear defense (CBRN) self-contained breathing apparatus (SCBA–13F), 14 CBRN air-purifying respirators (APR – 14G), 7 CBRN air-purifying escape respirators (APER–14G), 15 CBRN tight-fitting full facepiece powered air-purifying respirators (PAPR-14G) and 2 CBRN loose-fitting Powered air-purifying respirators (PAPR- 23C), for a total of 168 CBRN respirator certifications from 2005 through 2015.

PRODUCT STANDARDS

NIOSH research and expertise contributed to the National Fire Protection Association and other groups adopting improved standards for safer products, including firefighter self-contained breathing apparatus, ambulances, and truck cabs.

WORKER ROAD SAFETY

NIOSH helped sponsor the first International Conference on Workers on Roads, held in Washington, DC, in 2009, leading to new United Nations clauses about road safety for workers.

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SERVICES

Photo by Thinkstock

The Services (SVC) Sector is highly diverse in job categories, and it includes industries such as government services, automotive repair, hotels and restaurants, education, recreation, and waste collection. U.S. workers in the SVC sector are exposed to substances such as asbestos; cleaning solvents; carbon monoxide; diesel exhaust; tobacco smoke; and physical stressors, such as temperature extremes, overexertion, assaults, and other forms of violence. Other safety hazards within the sector include electrocution; motor vehicle crashes; and slips, trips, and falls.

The Service Sector Council includes 16 extramural members; four represent unions, four represent companies, two represent non-profit organizations, four represent government, and two are professors. Industries represented are nail salons, waste collection, recreation, hotels, restaurants, schools, auto-body shops, and communication workers. Intramural members include those with various backgrounds from most NIOSH divisions.

Trends in Services Employment, Fatalities, Injuries, and Illnesses

To provide context for the review of the SVC activities, effectiveness, and impact during the decade, background rates for employment in the sector,

Reducing Worker Disease and Death From Spray-on Truck Bed Liner Applications

At more than 2,000 truck manufacturers in the United States, more than 10,000 workers spray polyurethane coatings onto truck beds to create a resistant liner, facing potential exposure to the chemical MDI (methylene bisphenyl isocyanate). If inhaled in large-enough quantities, MDI can cause asthma and other respiratory diseases—and even death when overexposure is extreme.

To better measure the amount of MDI and similar chemicals in workplace air, NIOSH developed sampling methods. NIOSH also studied ways to develop and evaluate engineering control strategies to protect workers from potential hazardous exposures associated with spray on truck bed liners. To inform employers and workers about the dangers of spray-on truck bed liner operations and how to prevent over-exposures, NIOSH published these research results and recommendations on personal protective equipment in a NIOSH Alert.

The NIOSH sampling methods were adopted by international standards organizations, so risks of over-exposure to MDI can be detected and corrective actions taken. The NIOSH Alert helped inform an influential industry organization of the dangers, and it provided proven solutions for spray-on truck bed-liner operations, and it is an important information source on the organization's extensive safety-related website.

Details: Isocyanates and Spray Truck Bed Liner: Health

IMPROVING SAFETY E-TOOL

A NIOSH study of a restaurant-safety e-tool led the Occupational Safety and Health Administration to revise it to improve its relevance to young Hispanic and African-American restaurant workers.

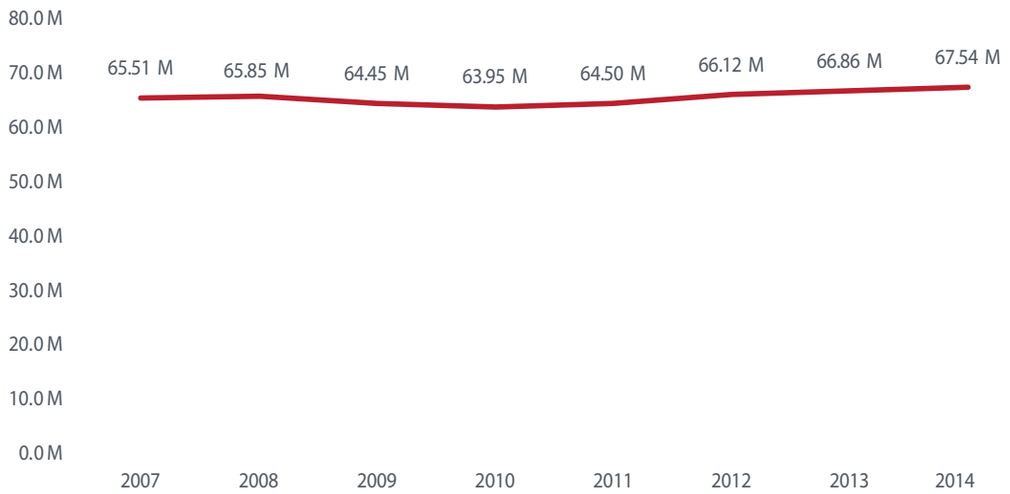
WET CLEANING PROCESS

NIOSH efforts led, in part, to three dry-cleaning companies adopting a "wet cleaning" process to reduce worker exposures to chemicals in dry cleaning.

fatalities, and nonfatal injuries are provided. From 2007 through 2014, employment in the SVC sector remained fairly stable (Figure 36). Employment data were collected from the Current Population Survey and includes private industry and government (federal, state, and local) and the self-employed. Volunteers are not included in employment counts.

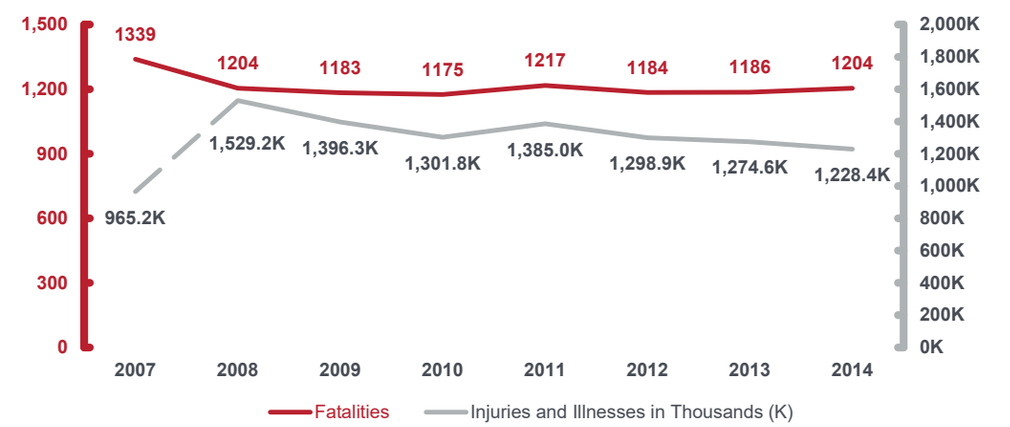
Fatalities declined between 2007 and 2008, with them leveling off after 2008 (Figure 37). Nonfatal injuries and illnesses (Figure 37) decreased between 2008 and 2010 before rising slightly and then decreasing to a low for the decade in 2014 of a little more than 1.2 million incidences (Figure 37). Fatality and injury data were collected from the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Injuries and Illnesses (SOII). The latter does not include self-employed, and only private industry data were available before 2008.

Figure 36. Employment trend in services (2007 through 2014)



Employment data: Bureau of Labor Statistics, Current Population Survey (CPS).

Figure 37. Fatality, injury or illness trends in services (2007 through 2014)



Fatality data: Bureau of Labor Statistics, Census of Fatal Occupational Injuries (CFOI). Injury or illness data: Bureau of Labor Statistics, Survey of Occupational Injuries and Illnesses (SOII).

Activities and Output

Figure 38 shows how many research projects (intramural and extramural) contributed effort to the SVC Sector Program during the decade. Project counts reflect the percentage of total effort directly attributable to SVC Sector Program research. Example: If one project is attributed as 50% effort in SVC, then it is counted as 0.50 of a project.

Figure 38. Number of services research projects (FY2007 through FY2015)

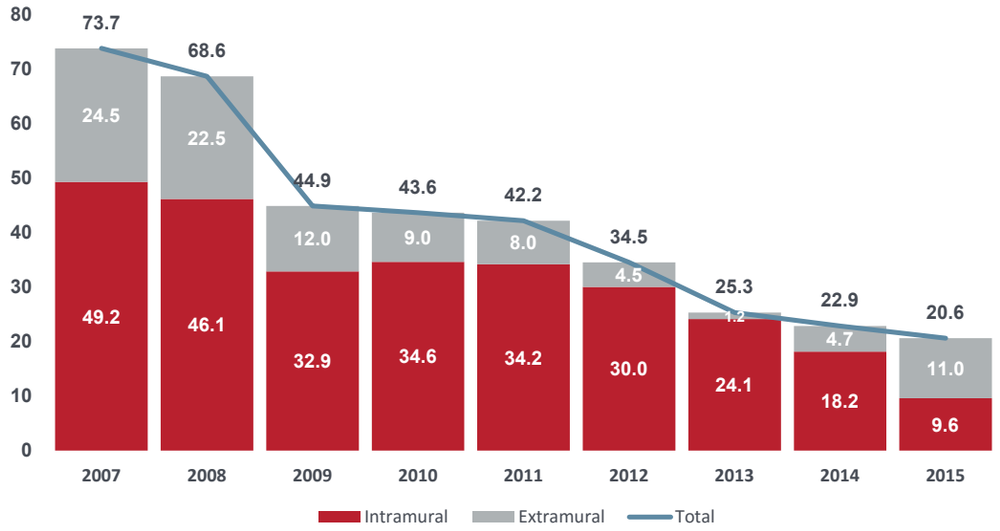
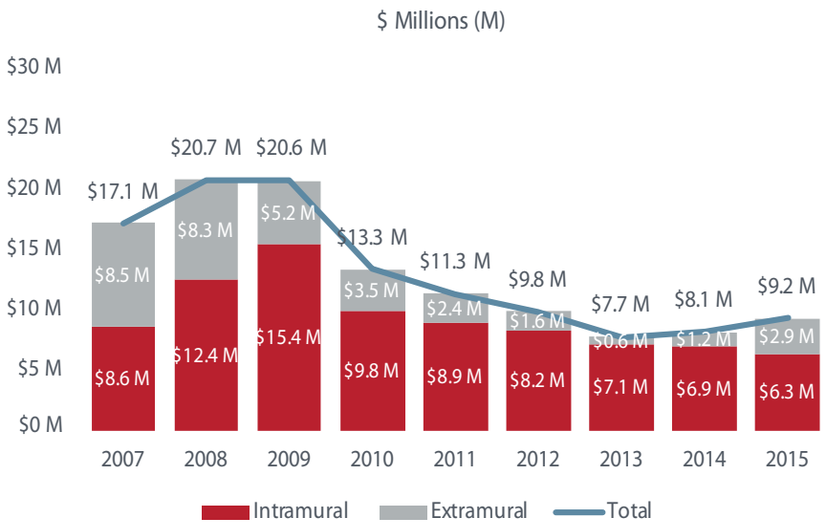


Figure 39 shows the funds invested in intramural and extramural research projects from 2007 through 2014. Investment totals reflect the percentage of total effort directly attributable to SVC Sector Program research goals. Example: If one project with a total budget of $100,000 is attributed as 50% effort in SVC, then the total investment is shown as $50,000. Totals in Figure 39 are shown in millions of dollars.

Figure 39. NIOSH investment in services research projects (FY2007 through FY2015)



SAFETY CHECKLIST

The NIOSH safety checklist program improved protections for school workers after adoption by the Massachusetts Department of Education, the state of Michigan, and the World Health Organization.

INJURY CLASSIFICATION

Academic, state, federal and other groups use the NIOSH online Occupational Injury and Illness Classification System to interpret occupational injury statistics and assign codes in occupational injury surveillance systems.

SCHOOL LAB SAFETY

The "NIOSH School Chemistry Laboratory Safety Guide" protects more chemistry teachers and students after adoption by the Occupational Safety and Health Administration, the American Industrial Hygiene Association, the National Science Teachers Association, and high school programs.

IMPROVED REGULATIONS

NIOSH science contributed to new federal, state, and municipal regulations to protect workers, including federal child labor law revisions, state workplace violence prevention laws, city ordinances for taxicab cameras, and the Occupational Safety and Health Administration's new recordkeeping rule, Youthbuild.

Information on research associated with the cross-sector programs is available for FY2007 through FY2014. The cross-sector programs are described later in this supplement. Figure 40 shows SVC research by cross-sector. A research project is counted if at least 50% of project activity is attributed to the SVC Sector Program and the corresponding cross-sector program. Cross-sector data are shown for five projects or more during the decade.

Figure 40. Number of projects by NIOSH cross-sector program for services (FY2007 through FY2014)

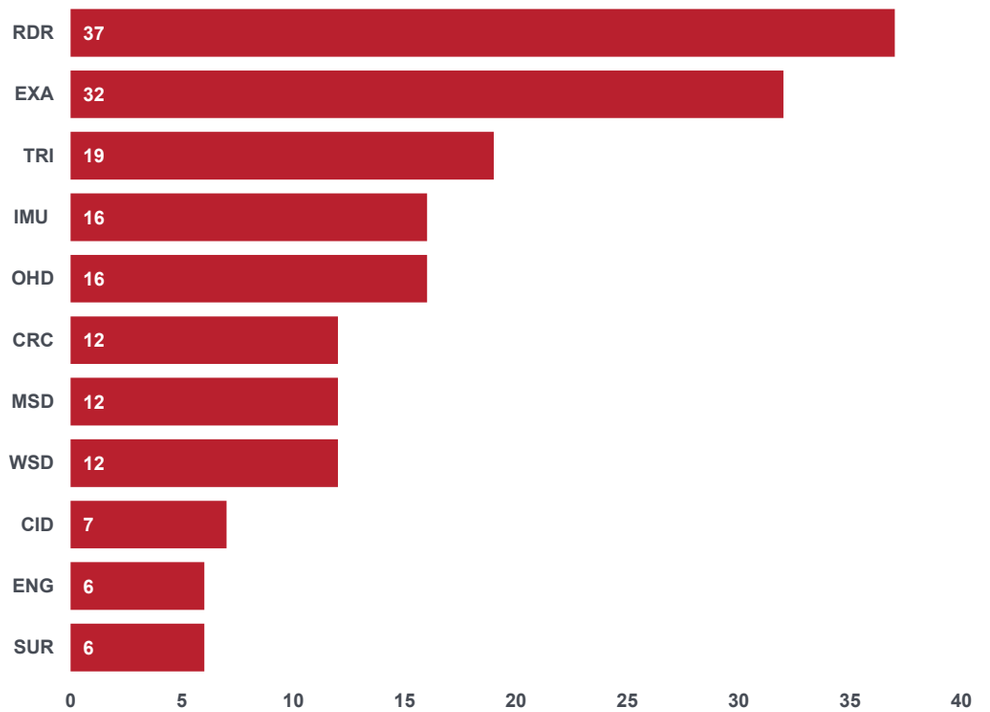


Table 29 shows the number and type of publications during the decade that were attributed to the SVC sector. Publications were identified in the NIOSHTIC-2 database of occupational safety and health publications, documents, grant reports, and other communication products supported in whole or in part by NIOSH funding. Publication counts likely underestimate publications produced by the program during NORA's second decade due to the limitations of the data-collection methods available. Not all publications a program develops are included in the NIOSHTIC-2 database, and not all publications in the database can be associated with a specific program. During the second decade, 261 publications were attributed to the SVC Sector Program, with the intramural publication count (211) being significantly greater than extramural (52).

Table 29. Publications attributed to services by type (FY2007 through FY2014)

Publication Category	Total Number Publications	Intramural Publications	Extramural Publications
Journal article	167	123	45
NIOSH-numbered publication or field study report	25	25	0
Abstract and conference proceeding	52	48	4
Book or book chapter	6	5	1
Newsletter, trade, or lay publication	5	5	0
Other	6	5	2
Totals	261	211	52

Note: The sum of intramural and extramural publications may exceed the total. A publication with intramural and extramural authors is counted in both categories.

Effectiveness

One measure of research effectiveness is the degree to which research activities addressed strategic goals of the SVC Program. Information on the sector goals addressed by a project is available for some NIOSH research projects. Table 30 shows how many projects addressed each strategic goal during the decade. The most-frequently addressed strategic goal (SG) was SG 08 (Government). SG 18 (Hair and nail salons), which was recently developed during FY2014, was one of the least-frequently addressed strategic goals. Intramural research projects most-frequently addressed SG 08, followed closely by SG 02 (Building Services). Extramural projects most-frequently addressed SG 16 (Musculoskeletal Disorders in all subsectors).

Table 30. Number of services research projects by strategic goal (FY2007 through FY2014)

Strategic Goal (SG)	Intramural Projects	Extramural Projects	Total Number of Projects
SG 01: Automotive repair	5	2	7
SG 02: Building services	21	1	22
SG 03: Health disparities in building services	5	0	5
SG 04: Education	19	0	19
SG 05: Hotel and motel worker injury	5	1	6
SG 06: Hotel and motel worker	14	0	14
SG 07: Health disparities in hotel and motel	2	0	2
SG 08: Government	22	1	23

(Continued)

ACCELERATOR SAFETY

A NIOSH-funded, state-based Fatality Assessment and Control Evaluation improved safety for mechanics who work on vehicles with left-accelerator pedals. For example, a manufacturer changed its design to prevent auto mechanics from accidentally depressing the left accelerator instead of the brake, and a car dealership instituted administrative controls to protect personnel servicing a car with a left-accelerator pedal.

RADIATION RISKS

NIOSH research on radiation safety led to the U.S. Customs and Border Protection Agency adopting Institute-developed training materials, and to the Transportation Security Administration accepting NIOSH risk information.

CHEMICAL EXPOSURE

NIOSH released a health hazard alert with the Occupational Safety and Health Administration to bring national attention to an issue, based on a Michigan report, of worker deaths from overexposure to the chemical methylene chloride while stripping bathtubs.

Table 30 (Continued). Number of services research projects by strategic goal (FY2007 through FY2014)

Strategic Goal (SG)	Intramural Projects	Extramural Projects	Total Number of Projects
SG 09: Traumatic injury in recreation and entertainment	1	0	1
SG 10: Food services injuries	7	1	8
SG 11: Violence in food service	1	0	1
SG 12: Telecommunications	8	0	8
SG 13: Traumatic injuries telecommunications	1	0	1
SG 14: Temporary and contingent workers	5	0	5
SG 15: Waste collection	3	3	6
SG 16: Musculoskeletal disorders in all subsectors	7	6	13
SG 17: Surveillance	12	0	12
SG 18: Hair and nail salons (new goal in 2014)	1	0	1

Note: Data show how many research projects contributed 50% or more effort to the sector goal. Projects can address multiple goals.

Outcomes and Impact

Citation of NIOSH-funded journal articles is one measure of research impact. This indicates that scientists outside of NIOSH have used the institute's research outputs. Table 31 shows journal articles associated with the SVC sector and their citation numbers available in the Scopus citation database as of September 2016. Data are shown for publications resulting from intramural and extramural research. Journal article numbers are lower than the total number noted in the publication table for this program. Not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Table 31. Number of citations for services (FY2007 through FY2014)

Type of Citation	Total
Total number of journal articles	152
Total number of citations	2,163
Intramural journal articles	110
Intramural citations	1,778
Extramural journal articles	43
Extramural citations	395

Note: Journal article counts included in this table are lower than the total number noted in the outputs table, because not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Another important measure of research outcomes is how many outputs others have obtained. Table 32 shows how many NIOSH-numbered publications associated with the SVC sector have been requested in printed form or downloaded electronically during NORA's second decade.

Table 32. Electronic and printed distribution of NIOSH-numbered services publications

Sector	Number of Publications	Electronic Downloads	Printed Distribution
Services	25	26,765	64,241

Additional sector program outcomes during the decade are described below.

- Initiated NIOSH research focus on using workers compensation data as a means for setting priorities and prevention. The two workshops that the sector council organized in 2009 and 2012 led to creating the NIOSH Center for Workers' Compensation Studies. The center has produced several publications that demonstrate the effectiveness of interventions in reducing the incidence, severity, and cost of injuries.
- A service sector project influenced child labor laws [Child labor regulations, 2010] to prevent children from operating balers.
- An autobody repair project influenced the ISO standard for isocyanate methods and a spray-on bed-liners alert influenced the American Chemistry Council to create in 2007 a safety-related website for the polyurethane industry.
- Several SVC sector projects have combined to influence public health policy regarding excluding asthmagens in cleaning chemicals. Work by NIOSH, the Association of Occupational and Environmental Clinics (AOEC), and state partners influenced Green Seal, a third-party certification organization, in 2008 to revise its environmental standard, GS-37 [Green Seal 2015]. The standard requires that to receive certification, cleaning products must exclude agents designated as sensitizers. In 2011, ECOLOGO®, another third-party certification organization, revised its standard to exclude these agents [ECOLOGO® 2011]. A women's and children's homeless shelter in California switched to asthma-safer chemicals.
- The Services Sector Council influenced a large hotel chain to allow housekeepers to use fitted sheets and mops with handles to improve worker's postures.
- NIOSH published a 2012 review of occupational injuries and fatalities among workers in the services sector industries, which highlighted subsectors with the highest fatality and injury rates
- The Bureau of Labor Statistics began in 2008 to include state and local governments in the annual Survey of Occupational Injuries and Illnesses. This was due, in part, to a suggestion by the sector council.
- NIOSH co-organized platform sessions on occupational safety and health for the solid-waste industry at international meetings hosted by the

LOCK OUT/TAG OUT

NIOSH studies of emergency-room injuries found that protective lock out/tag out devices improve safety, leading to the U.S. Department of Labor's proposed revisions to child labor regulations.

FLOOR-FINISHING SAFETY

NIOSH-funded research contributed to Massachusetts adopting a law to reduce the risk of serious or fatal burns for floor-finishing workers from flammable chemicals.

ISOCYANATE SAFETY

NIOSH research on the hazardous chemical isocyanate improved safety for auto workers by informing new ISO methods and standards.

CATERER SAFETY REPORTING

A NIOSH analysis of data from the Bureau of Labor Statistics contributed to the Occupational Safety and Health Administration removing a previous exemption allowed injuries and illnesses among school caterers to go unreported.

National Solid Waste Management Association and in 2012 by the Solid Waste Association of North America (SWANA).

- Trade journal articles were published on hazards and recommendations for waste collection workers. Additionally, the "drive safely" campaign to get homeowners to drive carefully around waste-collection workers was disseminated through mailed monthly bill statements.
- Thirteen safety and health articles were written and published for lawn and tree care trade journals in 2008, 2009, and 2010. Publications included Turf; Landscape Superintendent; Planet Advantage (2); Tree Care Industry Magazine (3); Pro, Lawn, and Landscape (3); Growing, Landscape Contractor, and Turf en Español (3). For grounds maintenance workers, the council published an article in MMWR about fatal injuries.
- The Services Sector Council, along with the Manufacturing Sector Council, hosted a joint meeting to discuss issues of temporary workers. The results of this meeting were disseminated as a NIOSH Science Blog article. The 2014 OSHA-NIOSH joint publication, "Recommended Practices for Protecting Temporary workers," [NIOSH 2014] was a starting point on this issue.
- Slips, trips, and falls of restaurant workers were assessed, and recommendations made to reduce those injuries through using slip-resistant shoes, among other solutions.

TRANSPORTATION, WAREHOUSING, AND UTILITIES (TWU)

The Transportation, Warehousing, and Utilities (TWU) Sector comprises establishments that transport passengers and cargo, whether by air, water, rail, ground, or pipeline; warehouse or store goods; and service, treat, or distribute electric power, natural gas, steam, water, or sewage. Traumatic injuries, musculoskeletal disorders, health and wellness, and hazardous exposures are the primary safety and health concerns for workers in this sector.

The vast scope of this sector is matched by the diversity and expertise of the sector council members and the council's partners. Program participants represent interests from academia; state, federal, and local governments; labor unions; nonprofits; trade associations, as well as NIOSH researchers.

The TWU Sector Program has a broad scope, with common themes related to injuries, fatalities, health and wellness, and exposures. Much of the research has focused on trucking, the largest constituent of the sector. Some results from the trucking-research efforts can be translated to other sub-sectors; however, the focus on trucking can leave other sub-sector partners feeling neglected. This issue has been addressed by hosting sub-sector-specific meetings. The sector leadership has changed several times during the second decade

Security Cameras Reduce Taxi Driver Homicides

Taxicab drivers face one of the highest homicide rates of any occupation. To reduce the risk, some cities require either a security camera in the cab, a partition between the driver and passengers, or both. In the first study to collect comprehensive data from a sample of the largest cities, NIOSH found a three-times lower homicide rate in the cities where taxicabs use security cameras than the control cities, and a seven-times lower homicide rate compared with pre-camera installation rates. The study found no effect for partitions, and a second NIOSH study using official crime reports had similar results.

The NIOSH studies are on an external partner's website that provides resources for taxi driver safety and other issues. The studies also informed a 2014 letter from the Philadelphia Fraternal Order of Police to the city's taxicab regulatory agency urging approval of an ordinance requiring cameras in cabs. Philadelphia adopted the improved safety equipment, and New Orleans and Montreal also made changes in light of the NIOSH results.

Details: Reducing Taxicab Homicides, and Homicide Prevention: How Many Drivers are Killed Each Year?

TRUCK DRIVER FATIGUE

NIOSH work to protect truck drivers led to some trucking companies adopting the Institute's fatigue-training webpage for driver education.

of NORA, resulting in changes in the overall management of the sector over time. Addressing the priority issues within the sector has been a constant.

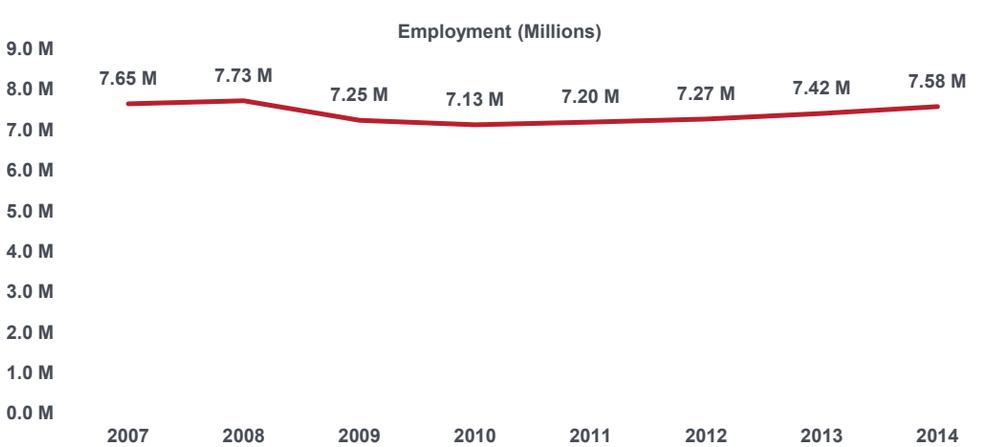
A national agenda was developed with four strategic goals: (1) reduce traumatic injury fatalities and injury rates, (2) reduce musculoskeletal disorders, (3) improve health and reduce premature mortality of workers, and (4) characterize and reduce hazardous exposures.

Trends in TWU Employment, Fatalities, Injuries, and Illnesses

To provide context for the review of the TWU activities, effectiveness, and impact during the decade, background rates for employment in the sector, as well as for fatalities and nonfatal injuries, are provided. From 2007 through 2014, employment in the TWU sector remained fairly stable (Figure 41). Employment data were collected from the Current Population Survey and includes private industry and government (federal, state, and local) and the self-employed. Volunteers are not included in employment counts.

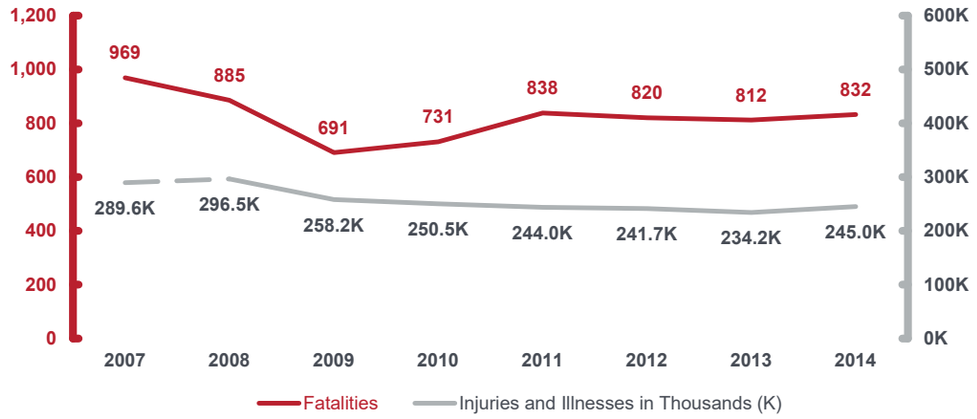
Fatalities significantly decline between 2007 and 2009 (Figure 42). However, fatalities increased substantially between 2009 and 2011 before leveling off. Nonfatal injuries and illnesses (Figure 42) gradually decreased between 2008 and 2013 to a low of around 234,000 before rising slightly in 2014. Fatality and injury data were collected from the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Injuries and Illnesses (SOII). The latter does not include, self-employed and only private industry data were available before 2008.

Figure 41. Employment trend in transportation, warehousing, and utilities (2007 through 2014)



Employment data: Bureau of Labor Statistics, Current Population Survey (CPS).

Figure 42. Fatality, injury or illness trends in transportation, warehousing, and utilities (2007 through 2014)

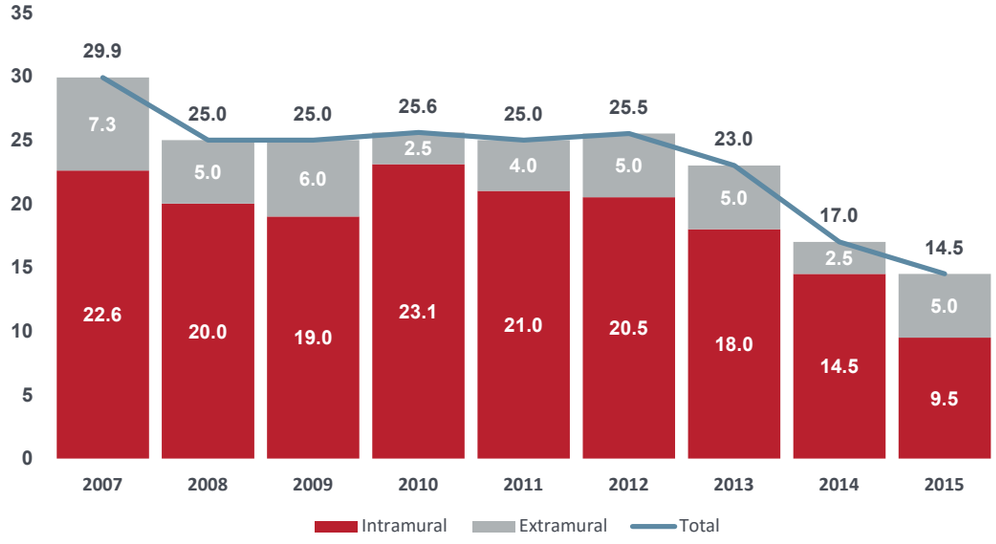


Fatality data: Bureau of Labor Statistics, Census of Fatal Occupational Injuries (CFOI). Injury or illness data: Bureau of Labor Statistics, Survey of Occupational Injuries and Illnesses (SOII).

Activities and Output

Figure 43 shows how many research projects (intramural and extramural) contributed effort to the TWU Sector Program during the decade. Project counts reflect the percentage of total effort directly attributable to TWU Sector Program research. Example: If one project is attributed as 50% effort in TWU, then it is counted as 0.50 of a project.

Figure 43. Number of transportation, warehousing, and utilities research projects (FY2007 through FY2015)



ALASKA AIRPLANE SAFETY

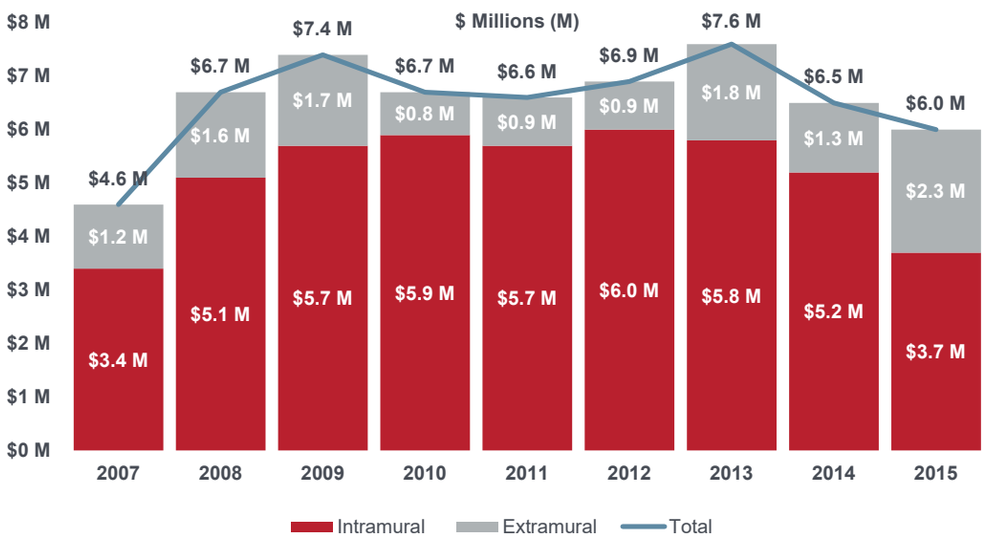
NIOSH research on commuter and taxi airplane accidents in Alaska led the National Oceanic and Atmospheric Administration to place weather cameras throughout the state.

PtD ADDED TO STANDARDS

Concepts from the NIOSH Prevention through Design (PtD) initiative have been added to more than 25 consensus standards. Among the groups developing these consensus standards are the American National Standards Institute (ANSI), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), American Society of Safety Engineers (ASSE), American Industrial Hygiene Association (AIHA), Underwriters Laboratory (UL), Semiconductor Equipment and Materials International (SEMI), and the International Organization for Standardization (ISO).

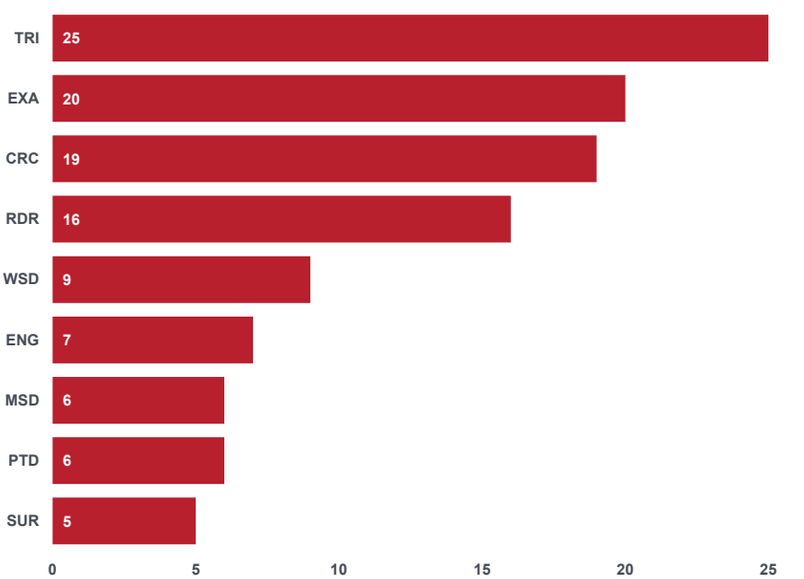
Figure 44 shows the funds invested in intramural and extramural research projects from 2007 through 2015. Investment totals reflect the percentage of total effort directly attributable to TWU Sector Program research goals. Example: If one project with a total budget of $100,000 is attributed as 50% effort in TWU, then the total investment is shown as $50,000. Totals in Figure 44 are shown in millions of dollars.

Figure 44. NIOSH investment in transportation, warehousing, and utilities research projects (FY2007 through FY2015)



Information on research associated with the cross-sector programs is available for FY2007 through FY2014. The cross-sector programs are described later in this supplement. Figure 45 shows the TWU research by cross-sector. A research project is counted if at least 50% of project activity is attributed to the TWU Sector Program and the corresponding cross-sector program. Cross-sector data are shown for five projects or more during the decade.

Figure 45. Number of projects by NIOSH cross-sector program for transportation, warehousing, and utilities (FY2007 through FY2014)



ELECTRONIC CIGARETTES

NIOSH responded to a request from the Occupational Safety and Health Administration (OSHA) to clarify how the skin absorbs nicotine from electronic cigarettes, contributing scientific information to OSHA developing a compliance action with an electronic-cigarette manufacturer.

Table 33 shows the number and type of publications during the decade that were attributed to the TWU sector. Publications were identified in the NIOSHTIC-2 database of occupational safety and health publications, documents, grant reports, and other communication products supported in whole or in part by NIOSH funding. Publication counts likely underestimate publications produced by the program during NORA's second decade due to the limitations of the data-collection methods available. Not all publications a program develops are included in the NIOSHTIC-2 database, and not all publications in the database can be associated with a specific program. During the second decade, 158 publications were attributed to the TWU Sector Program, with the intramural publication count (141) being significantly greater than extramural (17).

Table 33. Publications attributed to transportation, warehousing, and utilities by type (FY2007 through FY2014)

Publication Category	Total Number Publications	Intramural Publications	Extramural Publications
Journal article	90	78	12
NIOSH-numbered publication or field study report	25	25	0
Abstract or conference proceeding	33	29	4
Book or book chapter	3	3	0
Newsletter, trade, or lay publication	1	1	0
Other	6	5	1
Totals	158	141	17

Note: The sum of intramural and extramural publications may exceed the total. A publication with intramural and extramural authors is counted in both categories.

Sector activities in collaboration with partners have included:

- **Truck Manufacturers**—Anthropometric data collected by NIOSH are being used to redesign truck cabs to better fit today's drivers and increase their safety. See "Improved Safety for Truck Drivers: Designing Safer Cabs Based on Driver Body Dimensions."
- **Federal Aviation Administration**—Revisions of radio frequencies used by pilots in Alaska recommended by a working group were influenced by NIOSH analyses. Revisions were intended to reduce midair collisions and overlap in frequency usage between airports. See NIOSH and the Mid-Air Collision Avoidance Working Group Prevent Aircraft Collisions in Alaska.
- **Taxi Cab Regulators and Operators**—Use of security cameras has increased in response to NIOSH research demonstrating their association with reduced taxicab homicides.
- **Federal Motor Carriers Safety Administration and Federal Railroad Administration**—Hours-of-service rules have been influenced by NIOSH-supported research.
- **Trucking Companies**—Increased awareness of the multiple risk factors among truck drivers from NIOSH research has prompted trucking company actions on driver health and wellness programs.

TAXI CAMERAS WORK

NIOSH research found that in-cab cameras help protect taxi cab drivers from assault and robbery. The research contributed to improved regulations within some municipalities.

Effectiveness

One measure of research effectiveness is the degree to which research activities addressed strategic goals of the TWU Program. Information on the sector goals addressed by a project is available for some NIOSH research projects. Table 34 shows how many projects addressed each strategic goal during the decade. The most-frequently addressed strategic goal (SG) was SG 01 (Reduce Traumatic Injuries). SG 02 (Reduce Musculoskeletal Disorders) was the least-frequently addressed strategic goal. Intramural research projects most-frequently addressed SG 01. Extramural projects most-frequently addressed SG 04 (Hazardous Exposures).

Table 34. Number of transportation, warehousing, and utilities research projects by strategic goal (FY2007 through FY2014)

Strategic Goal	Intramural Projects	Extramural Projects	Total Number of Projects
SG 01: Reduce Traumatic Injuries	26	6	32
SG 02: Reduce Musculoskeletal Disorders	10	0	12
SG 03: Health and Wellness	12	3	15
SG 04: Hazardous Exposures	17	7	24

Data shows how many research projects contributed 50% or more effort to the sector goal. Projects can address multiple goals.

Outcomes and Impact

Citation of NIOSH-funded journal articles is one measure of research impact. This indicates that scientists outside of NIOSH have used the institute's research outputs. Table 35 shows journal articles associated with the TWU sector and their citation numbers available in the Scopus citation database as of September 2016. Data are shown for publications resulting from intramural and extramural research. Journal article counts are lower than the total number noted in the publication table for this program. Not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Table 35. Number of citations for transportation, warehousing, and utilities (FY2007 through FY2014)

Types of Citations	Total
Total number of journal articles	76
Total number of citations	1,057
Intramural journal articles	64
Intramural citations	903
Extramural journal articles	12
Extramural citations	154

Note: Journal article counts included in this table are lower than the total number noted in the outputs table, because not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Another important measure of research outcomes is how many outputs others have obtained. Table 36 shows how many NIOSH-numbered publications associated with the TWU sector have been requested in printed form or downloaded electronically during NORA's second decade.

Table 36. Electronic and printed distribution of NIOSH-numbered transportation, warehousing, and utilities publications

Sector	Number of Publications	Electronic Downloads	Printed Distribution
Transportation, Warehousing, and Utilities	17	17,996	3,471

CHEMICALS HARM HEARING

NIOSH research on chemicals that can damage hearing contributed to actions by several organizations, including the American Conference of Governmental Industrial Hygienists, the American College of Occupational and Environmental Medicine, and the U.S. Army Center for Health Promotion and Preventive Medicine.

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WHOLESALE AND RETAIL TRADE


Photo by Thinkstock

The Wholesale and Retail Trade (WRT) Sector comprises establishments involved with retail or wholesale sales of merchandise, generally without transformation, and rendering services incidental to the sale of merchandise. Workers in this sector, including many young employees, face risks that include workplace violence, overexertion, motor vehicle, and acute injuries associated with falls, machinery, shift work, and psycho-social stressors.

The WRT intramural steering council included representatives from six of the NIOSH research divisions. Each steering committee member had knowledge related to one or more of the six WRT strategic goals. Reaching extramural partners was more challenging, because at the beginning of the decade many businesses in this sector appeared to show little awareness or attention to workplace safety and health. To generate interest, the WRT

Retail Stores Reach for Safety

Overexertion injuries are common in the retail trade. According to the U.S. Bureau of Labor Statistics, 11,240 serious overexertion injuries occurred at grocery stores throughout the United States in 2014, and 42,720 occurred in retail trade establishments. Because each injury results in at least a day of lost work, it can be costly for the business owners and the worker. Typically, these types of strain injuries are associated with heavy lifting, repeatedly bending at the waist, bending at the waist while twisting the body, working while bent over at the waist, pushing and pulling or carrying heavy objects, and reaching. Many self-leveling carts and other devices can help workers with these tasks while minimizing the strain, but their design is better-suited to manufacturing or warehousing workplaces than the customer-filled aisles of a store.

NIOSH took a business-to-business approach in a series of three workshops to introduce retailers to manufacturers of devices willing to consider design changes to meet the needs of employees in grocery stores. The widely publicized NIOSH publication, "Ergonomic Solutions for Retailers" [NIOSH 2015a], gives examples of devices incorporating these design changes.

To address their increased risk for work-related injury, the WRT Program developed a new webpage for young retail workers. This webpage includes safety tips for recognizing hazards and understanding the injuries they can cause, such as being struck by or stuck in an object or equipment; doing too much (overexertion); slips, trips, and falls; driving or riding incidents on the road; and workplace violence.

The workshops and the NIOSH ergonomic publication led to a dozen of the industry-leading retail chains contracting with different device providers to use, modify, or develop equipment.

For details, visit Wholesale and Retail Trade and Ergonomic Solutions for Retailers.

YOUNG WORKER SAFETY

NIOSH research to protect young and inexperienced workers led to a curriculum that stakeholders use to help these workers stay safe on the job.

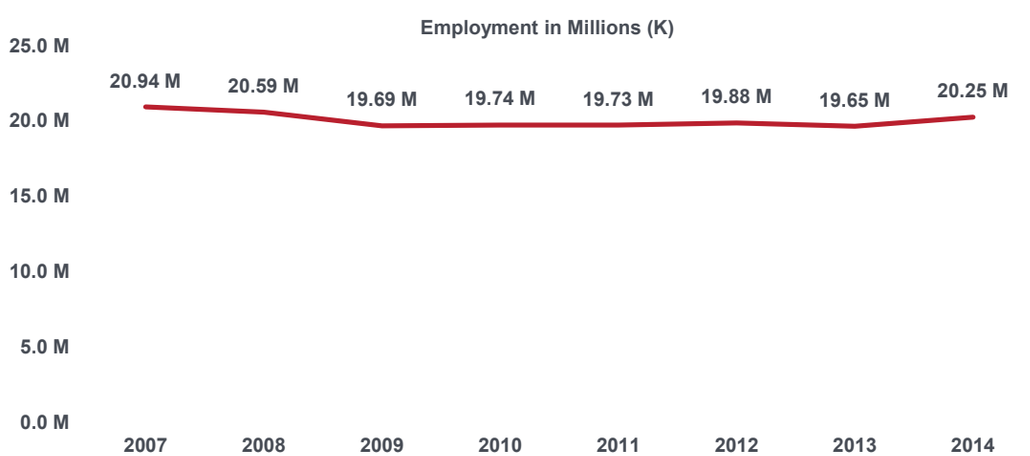
leadership sent multiple copies of existing NIOSH news clips about NORA and the WRT sector to a half-dozen large business publications that reached the desk and eyes of the executives of retail or wholesale businesses. As a result, 12 prominent employers responded to this meeting notice and subsequently attended, some becoming council members or extramural partners. In addition, the WRT Sector Council included two members from academia and three from the insurance industry. The major retail or wholesale and labor associations in this sector included the Loss Prevention Foundation (LPF); Retail Industry Leaders' Association (RILA); Food Marketing Institute (FMI); United Food and Commercial Workers (UFCW); Retail, Wholesale and Department Store Union (RWDSU); National Safety Council (NSC); and Material Handling Industry (MHI).

Trends in WRT Employment, Fatalities, Injuries, and Illnesses

To provide context for the Review of the WRT activities, effectiveness, and impact during the decade, background rates for employment in the sector, fatalities, and nonfatal injuries are provided. From 2007 through 2014, employment in the WRT sector remained fairly stable (Figure 46). Employment data were collected from the Current Population Survey and includes private industry and government (federal, state, and local) and the self-employed. Volunteers are not included in employment counts.

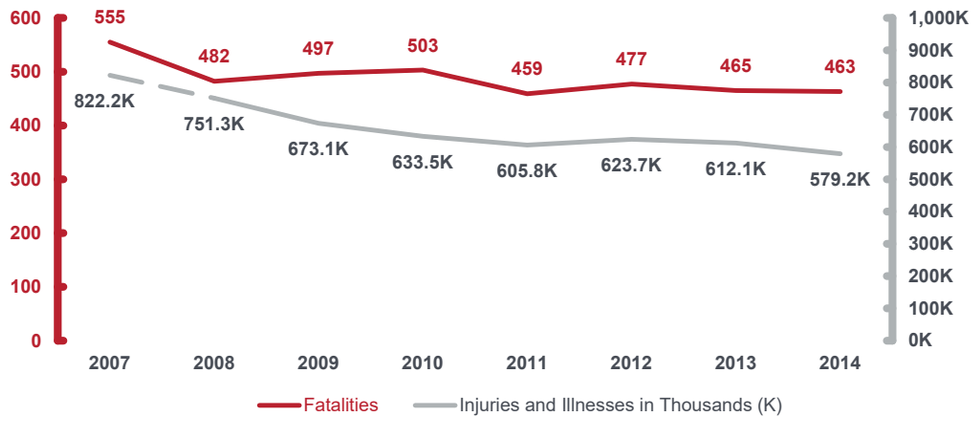
Fatalities declined slightly between 2007 and 2008, with numbers leveling off after this point (Figure 47). Nonfatal injuries and illnesses (Figure 47) decreased between 2008 and 2014. Fatality and injury data were collected from the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Injuries and Illnesses (SOII). The latter does not include self-employed, and only private industry data were available before 2008.

Figure 46. Employment trend in wholesale and retail trade (2007 through 2014)



Employment data: Bureau of Labor Statistics, Current Population Survey (CPS).

Figure 47. Fatality, injury or illness trends in wholesale and retail trade (2007 through 2014)



Fatality data: Bureau of Labor Statistics, Census of Fatal Occupational Injuries (CFOI). Injury or illness data: Bureau of Labor Statistics, Survey of Occupational Injuries and Illnesses (SOII).

Activities and Output

Figure 48 shows how many research projects (intramural and extramural) contributed effort to the WRT Sector Program during the decade. Project counts reflect the percentage of total effort directly attributable to WRT Sector Program research. Example: If one project is attributed as 50% effort in WRT, then it is counted as 0.50 of a project.

Figure 48. Number of wholesale and retail trade research projects (FY2007 to FY2015)

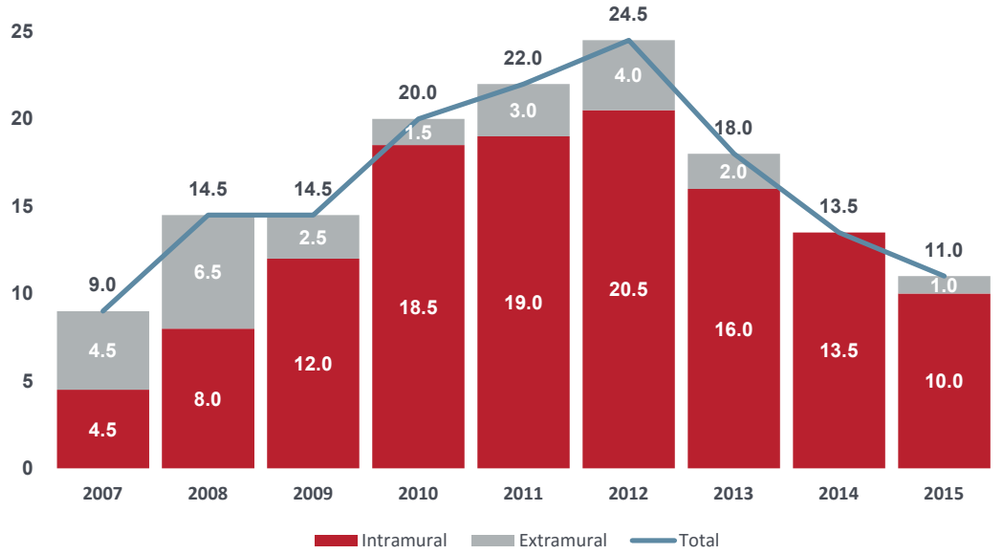


Figure 49 shows the funds invested in intramural and extramural research projects from 2007 through 2014. Investment totals reflect the percentage of total effort directly attributable to WRT Sector Program research goals. Example: If

VIRTUAL NANO CENTER

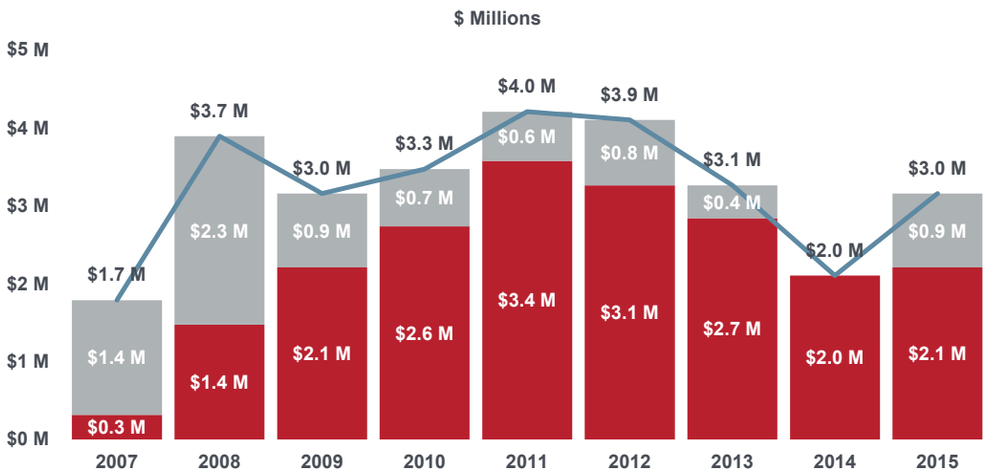
The NIOSH virtual Nanotechnology Research Center has supported or influenced more than 90 researchers in pioneering studies to better understand potential occupational health and safety risks in the nanotechnology industry, and to incorporate effective precautions as the industry grows.

STRATEGY HELPS INDUSTRY

A NIOSH-developed cost-collection strategy helps businesses like Ford Motor Company to determine costs of work-related injuries and illnesses.

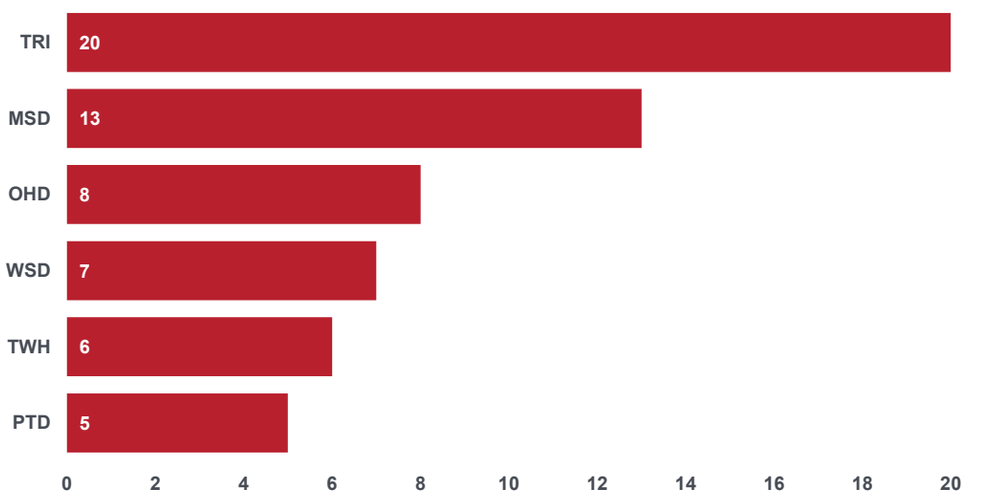
one project with a total budget of $100,000 is attributed as 50% effort in WRT, then the total investment is shown as $50,000. Totals in Figure 49 are shown in millions of dollars.

Figure 49. NIOSH investment in wholesale and retail trade research projects (FY2007 through FY2015)



Information on research associated with the cross-sector programs is available for FY2007 through FY2014. The cross-sector programs are described later in this supplement. Figure 50 shows the WRT research by cross-sector. A research project is counted if at least 50% of project activity is attributed to the WRT Sector Program and the corresponding cross-sector program. Cross-sector data are shown for five projects or more during the decade.

Figure 50. Number of projects by NIOSH cross-sector program for wholesale and retail trade (FY2007 through FY2014)



EMERGENCY RESPONSE

NIOSH developed the "Emergency Responder Health Monitoring and Surveillance" document, leading to the National Response Team adopting and implementing it based on NIOSH training.

Table 37 shows the number and type of publications during the decade that were attributed to the WRT sector. Publications were identified in the NIOSHTIC-2 database of occupational safety and health publications, documents, grant reports, and other communication products supported in whole or in part by NIOSH funding. Publication counts likely underestimate publications produced by the program during NORA's second decade due to the limitations of the data-collection methods available. Not all publications a program develops are included in the NIOSHTIC-2 database, and not all publications in the database can be associated with a specific program. During the second decade, 49 publications were attributed to the WRT Sector Program, with the intramural publication count (42) being significantly greater than extramural (8).

Table 37. Publications attributed to wholesale and retail trade by type (FY2007 through FY2014)

Publication Category	Total Number Publications	Intramural Publications	Extramural Publications
Journal article	25	18	8
Numbered publication or field study report	7	7	0
Abstract or conference proceeding	10	10	0
Book or book chapter	3	3	0
Newsletter, trade, or lay publication	3	3	0
Other	1	1	0
Totals	49	42	8

Note: The sum of intramural and extramural publications may exceed the total. A publication with intramural and extramural authors are counted in both categories.

Effectiveness

One measure of research effectiveness is the degree to which research activities addressed strategic goals of the WRT Program. Information on the sector goals addressed by a project is available for some NIOSH research projects. Table 38 shows how many projects addressed each strategic goal during the decade. The most-frequently addressed strategic goal (SG) was SG 01 (Reduce Musculoskeletal Disorders). SG 04 (Motor Vehicle Injuries) was the least-frequently addressed strategic goal. Intramural research projects most-frequently addressed SG 01. Extramural projects most-frequently addressed SG 03 (Workplace Violence).

Table 38. Number of wholesale and retail trade research projects by strategic goal (FY2007 through FY2014)

Strategic Goal (SG)	Intramural Projects	Extramural Projects	Total Number of Projects
SG 01: Reduce musculoskeletal disorders	13	1	14
SG 02: Traumatic injury due to slips, trips, and falls and contact with objects	8	1	9
SG 03: Workplace violence	3	3	6

(Continued)

EMERGENCY PLANNING

The NIOSH-developed control-banding process of workplace-risk management informs some stakeholders' emergency-preparedness plans.

Table 38 (Continued). Number of wholesale and retail trade research projects by strategic goal (FY2007 through FY2014)

Strategic Goal (SG)	Intramural Projects	Extramural Projects	Total Number of Projects
SG 04: Motor vehicle injuries	1	0	1
SG 05: Small businesses	6	0	6
SG 06: Vulnerable/Contingent Workers	11	0	11

Data shows how many research projects contributed 50% or more effort to the sector goal. Projects can address multiple goals.

Outcomes and Impact

Citation of NIOSH-funded journal articles is one measure of research impact. This indicates that scientists outside of NIOSH have used the institute's research outputs. Table 39 shows journal articles associated with the WRT sector and their citation counts available in the Scopus citation database as of September 2016. Data are shown for publications resulting from intramural and extramural research. Journal article counts included in this table are lower than the total number noted in the publication table for this program. Not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Table 39. Number of citations for wholesale and retail trade (FY2007 through FY2014)

Type of Citation	Total
Total number of journal articles	22
Total number of citations	206
Intramural journal articles	16
Intramural citations	104
Extramural journal articles	7
Extramural citations	107

Note: Journal article numbers included in this table are lower than the total number noted in the outputs table, because not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

SAMPLING TOOLKIT

A NIOSH environmental sampling toolkit and training materials help employers train emergency first responders.

Another important measure of research outcomes is how many outputs others have obtained. Table 40 shows how many NIOSH-numbered publications associated with the WRT sector have been requested in printed form or downloaded electronically during NORA's second decade.

Table 40. Electronic and printed distribution of NIOSH-numbered wholesale and retail trade publications (FY2007 through FY2014)

Sector	Number of Publications	Electronic Downloads	Printed Distribution
Wholesale and Retail Trade	7	3,317	3,297

Additional sector outcomes during the second decade are described below.

The WRT Sector opened new communication channels with four key wholesale or retail trade associations as a means of improving outreach to this underserved sector. This effort began with the first signed Letter of Agreement with the Loss Prevention Foundation (LPF). The Loss Prevention Foundation was established to train and certify retail and wholesale business leaders in loss prevention, which includes safety engineering and risk management. The agreement highlighted NIOSH's vast informational resources relevant to the Loss Prevention Foundation certification program. The Loss Prevention Foundation also hosted NIOSH publications on its website and prepared articles highlighting NIOSH research for its membership. Similar Letters of Agreement were signed with the Retail Industry Leaders Association (RILA), Food Marketing Institute (FMI), and the Material Handling Institute (FMI). The agreements not only served as conduits for sharing information, but they gave opportunities for the WRT Program to (1) experience face-to-face encounters with the associations' membership (employers), (2) attend normally closed national conferences, (3) gain visibility from NIOSH WRT presentations, and (4) hold exhibits at these conferences. As a result, the WRT sector leadership was exposed to business culture and safety practices of the associations, which was important in developing and marketing WRT products. Although it is difficult to estimate the extent or impact that followed from these agreements, it was clear NIOSH was viewed as a trusted resource for employers who were seeking solutions to their most important and costly problem—preventing musculoskeletal disorders (MSDs) associated with manual material-handling jobs.

The WRT sector was instrumental in engineer controls being implemented to reduce injuries from manual material-handling jobs because of matching businesses with solutions to those businesses with problems. The WRT leadership, with help from the above-mentioned business and trade associations, launched a campaign to bring "solution providers" together with "solution seekers" to find new cost-effective approaches for reducing MSD injuries associated with manual materials-handling jobs. Three NIOSH/WRT workshops were held with national expos featuring material-handling equipment. Each workshop was promoted as a "business-to-business" event that focused on preventing MSD injuries. Experts on material handling and ergonomics were there to give ideas and solutions to employers. A few notable outcomes from these workshops included a collection of best practices involving the use of

lift-assisting devices, which were also included in the NIOSH publication, "Ergonomic Solutions for Retailers" [NIOSH 2015a]. More importantly, the workshops generated agreements with key employers for developing or implementing engineering controls. These engineering controls consisted of mechanical-assist devices to reduce MSD injuries associated with manual material-handling jobs.

The WRT leadership produced six key NIOSH publications, including three peer-reviewed journal articles, and three NIOSH-numbered publications. The WRT leadership also produced six employer-oriented articles published in trade journals and magazines, along with WRT News Bulletins that were sent to both trade organizations, current and former members of the sector council, and academics. Finally, the WRT Leadership and steering council members are preparing two more NIOSH publications for release in 2016 and 2017, "New Retail Workers: Safety and Health at Work," and "Ergonomic Practices for Product Packaging in Small Businesses: Application for Manufacturing, Wholesale, and Retail Trade Sector." The primary challenge involved the cost and logistics of holding meetings in a central location with a relevant purpose that justified the council member's time away from their jobs.

ALL SECTORS

Within the NIOSH program portfolio, some research projects contribute to most or all 10 of the NORA sectors. These projects are collectively labeled as the "All Sectors" research category.

The results discussed below capture the activities, effectiveness, and impact of this research during the second decade.

States Implement the NIOSH "Talking Safety" Curriculum for Young Workers

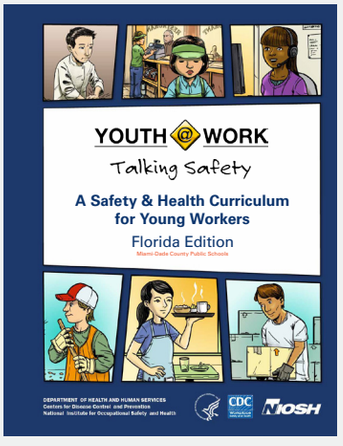
Every year, more than 100,000 young people ages 14 to 24 experience serious injuries and illnesses at work.

The NIOSH Safe-Skilled-Ready Workforce (SSRW) program aims to equip young people and new hires with basic work-readiness competencies to protect themselves on the job. The program researches the skills needed by young workers, helps schools and others add the missing skills training into their curricula for youth and new hires, and it evaluates the effectiveness of the training to improve it.

NIOSH updated and published 54 Youth@Work: Talking Safety curricula individually tailored for each U.S. state and territory, and the Miami-Dade County Public School System. NIOSH also developed and validated an online assessment tool (with the nonprofit National Occupational Competency Testing Institute, NOCTI) to measure the effectiveness of the curriculum. Tens of thousands of free copies of the state-specific versions of the Talking Safety curriculum have been downloaded from the NIOSH website.

NIOSH and state partners are implementing the curriculum in schools and maximizing impact. Florida and Oklahoma are working with NIOSH to roll out the curriculum statewide. NIOSH is also helping to train Connecticut Technical High School teachers on the curriculum. The Miami-Dade County Public School System is incorporating the curriculum into 8th grade science classes, and the school system is working with NIOSH to research the effectiveness of this work.

Details: Safe-Skilled-Ready Workforce Program



MANUAL OF METHODS

The NIOSH Manual of Analytical Methods continues to provide practitioners in the United States and internationally with new ways to monitor work-related exposures.

Activities and Output

Figure 51 shows how many research projects (intramural and extramural) contributed effort to the All Sectors category during the decade.

Figure 51. Number of all sectors research projects (FY2007 through FY2015)

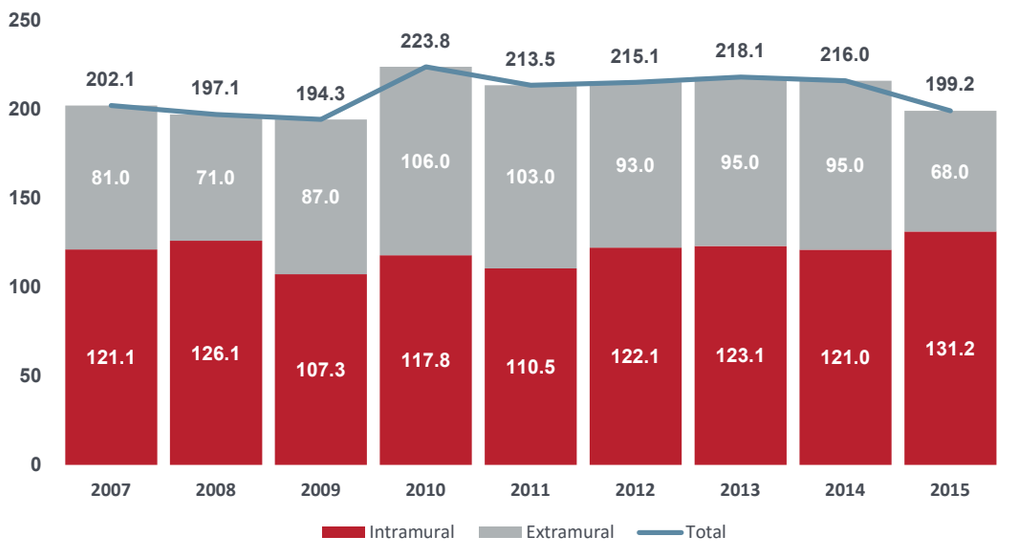
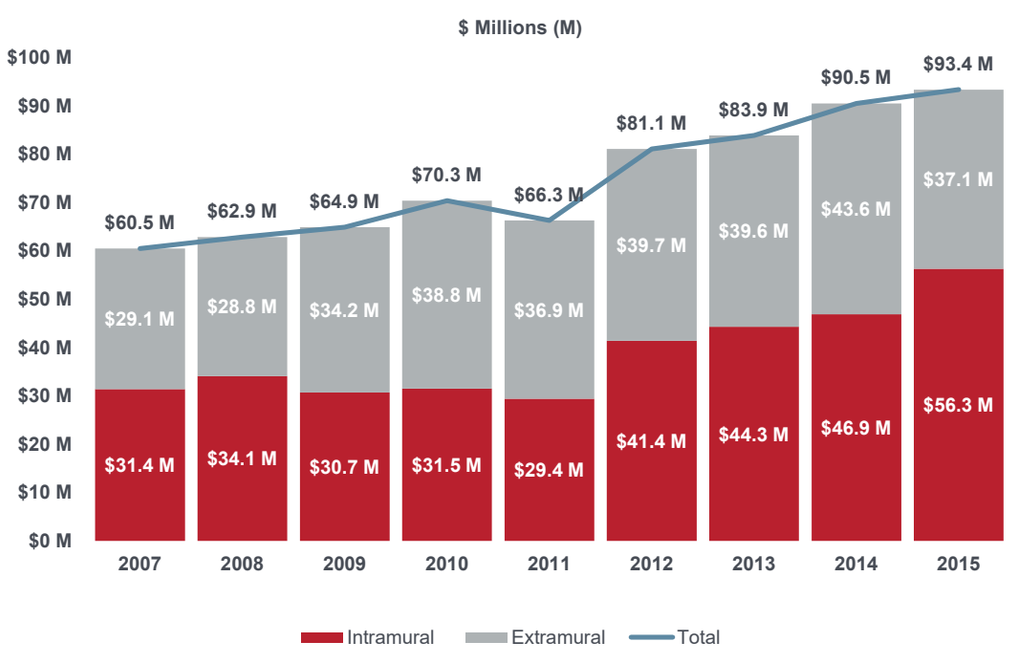


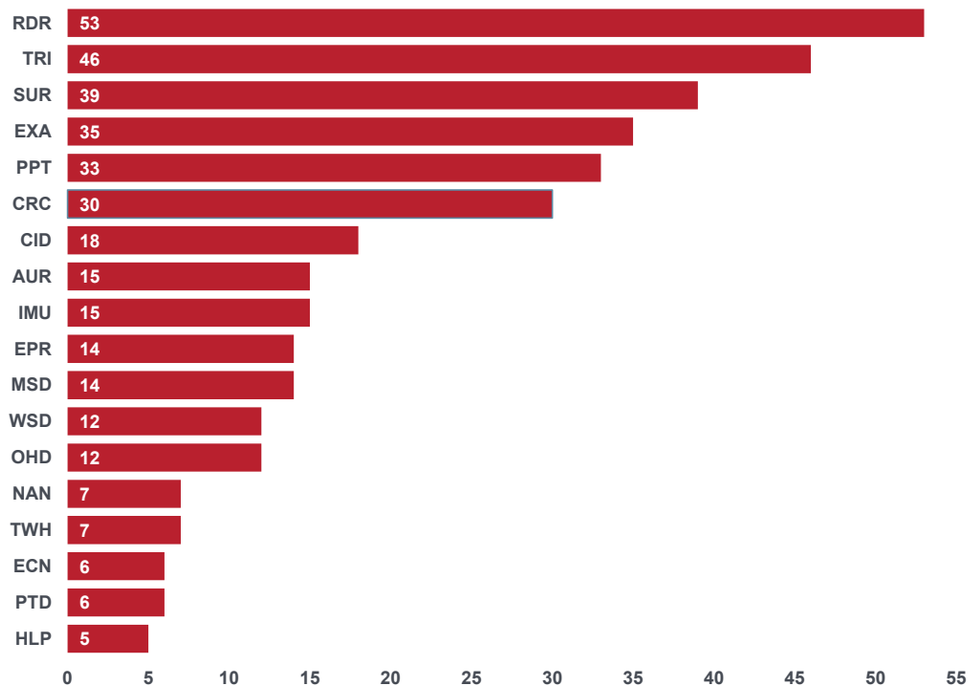
Figure 52 shows the funds invested in intramural and extramural All Sectors research projects from 2007 through 2015. Totals in Figure 52 are shown in millions of dollars.

Figure 52. NIOSH investment in all sectors research projects (FY2007 through FY2015)



Information on research associated with the cross-sector programs is available for FY2007 through FY2014. The cross-sector programs are described later in this supplement. Figure 53 shows the All Sectors research by cross-sector. A research project is counted if at least 50% of project activity is attributed to All Sectors and the corresponding cross-sector program. Cross-sector data are shown for five projects or more during the decade.

Figure 53. Number of projects by NIOSH cross-sector program for all sectors (FY2007 through FY2014)



Note: Projects counted were active from FY2007 through FY2014 and attributed 50% or more effort to the sector program.

Table 41 shows the number and type of publications during the decade that were attributed to the All Sectors category. Publications were identified in the NIOSHTIC-2 database of occupational safety and health publications, documents, grant reports, and other communication products supported in whole or in part by NIOSH funding. Publication counts likely underestimate publications produced by the program during NORA's second decade due to the limitations of the data-collection methods available. Not all publications a program develops are included in the NIOSHTIC-2 database, and not all publications in the database can be associated with a specific program. During the second decade, 1,657 publications were attributed to All Sectors, with the extramural publication count (1,228) being significantly greater than intramural (465).

SAMPLING SOFTWARE

NIOSH and other agencies used the Institute's environmental-sampling software in a full-scale Idaho National Laboratory bioterrorism-response exercise.

ANTHRAX CONTROLS

Protecting more than half a million postal workers, NIOSH-developed engineering controls implemented by the U.S. Postal Center to reduce the risk of anthrax exposure from contaminated mail in processing centers.

Table 41. Publications attributed to all sectors by type (FY2007 through FY2014)

Publication Category	Total Number Publications	Intramural Publications	Extramural Publications
Journal article	1,008	250	787
Numbered publication or field study report	161	102	59
Abstract or conference proceeding	116	55	62
Book or book chapter	81	33	49
Newsletter, trade, or lay publication	24	11	18
Other	267	14	253
Totals	1,657	465	1,228

Note: The sum of intramural and extramural publications may exceed the total. A publication with intramural and extramural authors is counted in both categories.

Effectiveness

One measure of research effectiveness is the degree to which research activities addressed strategic goals of a NORA program. Because research in All Sectors apply to all of the sector programs, it is not feasible to determine which strategic goals within each sector are addressed by these projects. Rather, Table 42 shows the number of these projects by research type in the following categories: (a) basic/etiological research, (b) Information, (c) Intervention research, (d) Surveillance, and (e) Training. This Information is available for some NIOSH research projects. Information generation was the most-frequent project type, followed by basic/etiologic research. The lowest number of projects was intervention research. Intramural projects were most-frequently categorized as information research. Extramural projects were most-frequently basic/etiologic research.

Table 42. Number of all sectors research projects by research type (FY2007 through FY2014)

Research Type	Intramural Projects	Extramural Projects	Total Number of Projects
Basic/Etiologic	34	68	102
Information	76	35	111
Intervention	2	7	9
Surveillance	2	33	35
Training	3	66	69

Projects can address multiple research types.

ACRYLAMIDE EXPOSURE

A NIOSH study with three companies that identified sources of acrylamide exposure led to the companies changing their operation procedures to lower workers' exposures.

Outcomes and Impact

Citation of NIOSH-funded journal articles is one measure of research impact. This indicates that scientists outside of NIOSH have used the institute's research outputs. Table 43 shows journal articles associated with the All Sectors category and their citation numbers available in the Scopus citation database as of September 2016. Data are shown for publications resulting from intramural and extramural research. Journal article counts included in this table are lower than the total number noted in the publication table for all sectors. Not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Table 43. Number of citations for all sectors (FY2007 through FY2014)

Type of Citation	Total
Total number of journal articles	888
Total number of citations	14,585
Intramural journal articles	205
Intramural citations	4110
Extramural journal articles	707
Extramural citations	10,819

Note: The journal article count included in this table is lower than the total number noted in the outputs table, because not all publications are included in the Scopus citation database. Journal articles attributed to both intramural and extramural projects are counted in both.

Another important measure of research outcomes is how many outputs others have obtained. Table 44 shows how many NIOSH-numbered publications associated with All Sectors have been requested in printed form or downloaded electronically during NORA's second decade.

Table 44. Electronic and printed distribution of NIOSH-numbered all sectors publications (FY2007 through FY2014)

Sector	Number of Publications	Electronic Downloads	Printed Distribution
All Sectors	67	108,059	227,214

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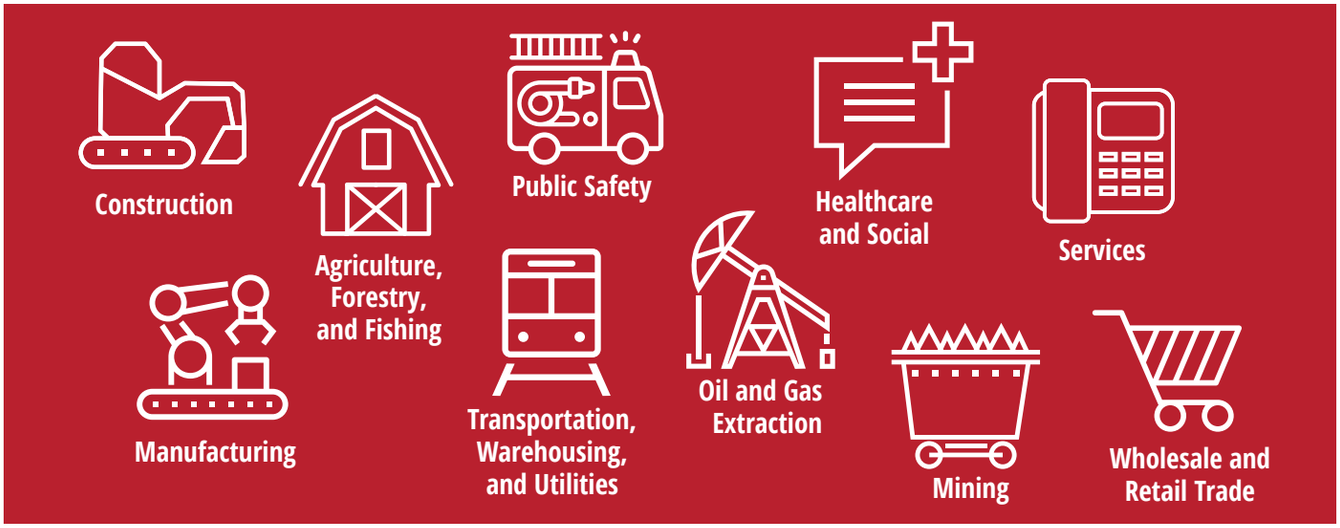
CROSS-SECTOR PROGRAM REVIEW



To enhance the 10 sector programs, NIOSH created cross-sector programs to identify national priorities for occupational health and safety research and facilitate efforts to address those priorities. Cross-sector programs were managed by NIOSH, and they were organized into health and non-health outcome areas to support the sectors in accomplishing their goals for the nation and coordinating priorities that affect multiple sectors. The health outcome cross-sectors represent the major occupational safety and health issues faced by workers, and non-health outcome cross-sectors represent research methods; approaches; and core activities, such as surveillance, hazard exposure, interventions, information dissemination and statutory programs [NIOSH 2010b].

This section summarizes the activities and impact these health-outcome cross-sectors and non-health-outcome cross-sectors have had on occupational safety and health over the decade.

Health-Outcome Cross-Sector Programs

Following are accomplishments of the seven health-outcome cross-sectors. The NIOSH Program Portfolio webpage and the program's website offer more information.

- Cancer, Reproductive, and Cardiovascular Diseases
- Hearing Loss Prevention
- Immune and Dermal Diseases
- Musculoskeletal Disorders
- Respiratory Diseases
- Traumatic Injury
- Work Organization and Stress Disorders

Non-health Outcome Cross-sectors

Following are accomplishments of the 14 non-health-outcome cross-sectors. The NIOSH Program Portfolio webpage and the program's website offer more information.

- Authoritative Recommendations
- Economics
- Engineering Controls
- Emergency Preparedness and Response
- Exposure Assessment
- Global Collaborations
- Health Hazard Evaluation
- Nanotechnology
- Occupational Health Disparities
- Personal Protective technology
- Prevention through Design
- Small Business Assistance and Outreach
- Surveillance
- Total Worker Health®

Health-Outcome Cross-Sector Programs

Cancer, Reproductive, and Cardiovascular Diseases

The chief health areas of concern for the Cancer, Reproductive, and Cardiovascular Diseases (CRC) Program are cancer, reproductive health, heart disease, and evolving areas of occupational neurological and renal disease. The program addresses these by researching health and exposure in working populations, providing data for developing standards, recommending interventions to control health hazards, conducting basic and applied laboratory research to investigate precursors of occupational disease, developing engineering controls and interventions for workplace hazards, and developing and disseminating information to foster prevention of occupational disease.

The CRC Program involves the work of all NIOSH Divisions, Labs, and Offices. NIOSH scientists work with extramural partners, including professionals representing federal, state, and local governments; labor; industry; academia; or other research organizations and professional associations.

For many disease endpoints, the connection between investigating work-related illnesses and end-impact is often indirect and can span many years; this fact is reflected in the types of most-common impact from research in the CRC Program.

Further activities during the decade are described below.

- Published findings from many studies of workplace-related cancer have been used by authoritative groups to help set national and international standards. Recent examples include (1) in 2013, designation of diesel exhaust by the International Agency for Research on Cancer (IARC) as a Group 1 (known human) carcinogen; (2) in 2012 and 2013, the National Toxicology Program used evidence from CRC studies in its 2013 Report on Carcinogens to classify the chemical ortho-toluidine as "reasonably anticipated to be a human carcinogen" [NTP 2014]; and (3) CRC studies were also influential in IARC's recent determination of PCBs and chlorinated solvents to be Group 1 carcinogens.

Preventing Work-Related Reproductive Problems and Cardiovascular Disease

For many diseases, the connection with work-related exposures requires research that spans many years. In NORA's second decade, NIOSH researchers collaborated with many academic centers and large epidemiologic studies to assess work-related risk factors for reproductive problems and cardiovascular disease. For reproductive health, these collaborations have added significantly to the body of knowledge in the past decade. Collaborations include the National Birth Defects Prevention Study and the Nurses' Health Study. For cardiovascular health, collaborations include the Reasons for Geographic and Racial Differences in Stroke (REGARDS) Study, and the Buffalo Cardiometabolic Occupational Police Stress (BCOPS) study.

NIOSH research collaboration with the National Birth Defects Prevention Study provided critical information about the risk of birth defects from workplace exposure to chemicals. Researchers found that maternal exposure to solvents at work is associated with infant neural tube defects, some heart defects, and fetal growth restriction. It found no association with orofacial clefts. In the area of pesticides, researchers found that maternal exposure is associated with neural tube defects; gastroschisis, which is a defect of the abdominal wall; limb reductions; and some, but not all, heart defects. They did not find a statistical link between pesticide exposure and the urological birth defect in boys called hypospadias.

Details: National Birth Defects NIOSH Publications

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Preventing Occupational Cancer

Researchers estimate that 3% to 6% of U.S. cancers are work-related, which suggests that 44,000 to 87,000 work-related cancers are diagnosed each year in the United States. To date, only about 2% of chemicals processed in the United States have been tested for carcinogenicity, so the estimate of work-related cancers might have increased if more chemicals used in U.S. workplaces were tested.

Past NIOSH research identified physical and chemical agents in the workplace that are associated with cancer; including asbestos; benzene; benzidine; 1,3-butadiene; cadmium; chromium; crystalline silica; dioxin; formaldehyde; vinyl chloride; and others. NIOSH studies continue to find links between cancer and workplace exposure to certain chemicals, including beryllium, diesel exhaust, o-toluidine, 1-bromopropane. Among fire fighters, many other chemicals have links to cancer. This research informs recent guidance, by the World Health Organization and the National Toxicology Program, on work-related cancer. These leading organizations cited NIOSH publications documenting the cancer-causing potential of work-related chemical exposures.

Details: Occupational Cancer


Photo by Thinkstock

- Disseminated results of a "largest-of-its kind" cohort study of U.S. fire fighters. The study revealed higher-than-expected rates of overall cancer and of several specific cancers.
- Worked with state partners and other organizations on publications, such as the NIOSH Alert "Preventing Occupational Exposures to Antineoplastic and Other Hazardous Drugs in Health Care Settings" [NIOSH 2004], which was adopted by three states and one professional organization in the United States.
- Contributed to the CDC's National Public Health Action Plan for the Detection, Prevention, and Management of Infertility, highlighting areas that included occupational factors related to infertility.
- Completed the NIOSH Topic Page "Reproductive Health and the Workplace" [NIOSH 2015d], which serves as an international reproductive health resource.
- Participated with academic centers in assessing occupational risk factors potentially related to CRC health outcomes in large national studies. Such collaborations include the Birth Defects Study to Evaluate Pregnancy Exposures (BD-STEPS), Nurses' Health Study, Women's Health Initiative, REasons for Geographic and Racial Differences in Stroke (REGARDS), and the Buffalo Cardio-metabolic Occupational Police Stress (BCOPS) Study.
- Published results from the National Survey of U.S. Long-Haul Truck Driver Health and Injury. This work documented cardiovascular disease risk factors among long-haul truck drivers and suggested needed interventions.
- Published *NIOSH Current Intelligence Bulletin 67, Promoting Health and Preventing Disease and Injury Through Workplace Tobacco Policies* [NIOSH 2015b]
- Published many reports of laboratory work developing the scientific basis to explain occupational health effects resulting from occupational exposures and health outcomes, such as cancer, cardiovascular disease, and neurologic disease. Among these studies were several groundbreaking laboratory studies of potential for carcinogenicity of carbon nanotubes (CNT) and other nanoparticles.
- Completed data collection for an industrywide study of CNTs and nanofiber production workers. Published initial data on worker exposure to CNTs.

- Performed many investigations of fire-fighter deaths related to cardiovascular disease. CVD fatalities have been reduced 20% since 1999, when the medical component of the CRC NIOSH Fire fighter Fatality Investigation and Prevention Program (FFFIPP) began. The FFFIPP contributed to this reduction.

Hearing Loss Prevention

The NIOSH Hearing Loss Prevention (HLP) Cross-sector Program gives national and world leadership to reduce the prevalence of occupational hearing loss, through a focused program of research and prevention activities. NIOSH is the sole federal agency with primary responsibility for conducting research on occupational hearing loss, causal factors, and prevention methods. This program comprises an interdisciplinary team of audiologists, engineers, psychologists, and physicists who actively work to reduce hearing loss. The program strives to meet its objective by conducting high-quality research, developing practical solutions to complex problems that cause occupational hearing loss, fostering partnerships with key stakeholders, and promoting the transfer and translation of research to practice. During NORA's second decade, the program focused its efforts in four primary areas—prevention programs, engineering controls, hearing protection devices, and biologic and acoustic sources of hearing loss.

The HLP research cross-sector comprises researchers from the Division of Applied Research and Technology (DART), the Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS), the Office of Mine Safety and Health (OMSHR), the Education and Information Division (EID), and the Office of Extramural Programs (OEP). HLP has partnered with professional societies, such as the Acoustical Society of America, American Industrial Hygiene Association, National Hearing Conservation Association, American Academy of Audiology, Council for Accreditation in Occupational Hearing Conservation, Association for Research in Otolaryngology, American Speech Language Hearing Association, Institute for Noise Control Engineering, and the American Society of Mechanical Engineers. The HLP Program has actively engaged other federal agencies, particularly the U.S. Environmental Protection Agency, Department of Defense (Army, Air Force and Navy), Department of Labor (MSHA and OSHA), Department of Interior (Bureau of Reclamation and Bureau of Safety and Environmental Engineering), National Institutes of Health (National Institute on Deafness and Other Communication Disorders), Department of Education (National Center for Education Statistics), and CDC's National Center for Health Statistics. The HLP cross-sector has been involved with bodies that set consensus, through the American National Standards Institute

Testing Earplugs to Prevent Hearing Loss

Hearing loss is one of the most common work-related illnesses in the United States. Approximately 22 million workers endure hazardous noise levels at work, and an additional 9 million encounter chemicals that can damage hearing. In addition to the toll on worker health, work-related hearing loss is costly. Worker's compensation payments for hearing loss disability total an estimated $242 million annually. As first lines of protection, NIOSH recommends eliminating or reducing hazardous noise in the workplace at the source. Hearing protection devices (HPD) may be necessary as part of a strategy to prevent hearing loss. Previously, however, it was difficult to measure how well these devices worked.

To protect workers' hearing, NIOSH developed a method that measures the effectiveness of hearing protection devices and identifies workers who need better protection. Called HPD Well-Fit™, this method provides results within 10 minutes for any type of earplug. The only equipment needed is a computer running the Windows operating system (version 7 or later), with a high-definition sound card, a mouse with a scroll wheel, and sound-isolating headphones. HPD Well-Fit™ is now available for external partners to purchase.

Details: Measuring How Well Earplugs Work

(ANSI) and the International Standards Organization (ISO). Research has engaged several manufacturers in safety equipment (3M, Moldex Metric, Honeywell, Custom Protect Ear, and Westone Laboratories). Research has also engaged several mining equipment manufacturers (Joy Global Inc., Corry Rubber, Kennametal). HLP research has identified critical needs for advancing hearing-loss prevention research through surveillance, personal protection equipment, noise-control engineering, evidence-based best practices, and by studying other risk factors for hearing loss.

During the past decade, the HLP Cross-sector Strategic Plan had five goals: surveillance, personal protection equipment, noise-control engineering, evidence-based best practices, and other risk factors for hearing loss.

In surveillance, HLP established partnerships with hearing-conservation providers and developed new capabilities and estimates of the prevalence of occupational hearing loss in the United States. Several articles have been published by the Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS) Surveillance Branch. A new topic page devoted to Occupational Hearing Loss has been established. Participating in the National Health and Nutrition Examination Survey has led to establishing new databases for hearing levels as a function of age, gender, and ethnicity. These have been incorporated into the ISO 1999:2013 standard for estimating noise-induced hearing due to occupational noise exposure [ISO 2013].

In noise-control engineering, advanced capabilities have been added to the Office of Mine Safety and Health (OMSHR) hearing-loss prevention branch. These capabilities came in the form of beam-forming arrays to identify noise sources in machinery, a new hemi-anechoic chamber for studying mining equipment, and analysis and prediction capabilities for source-path contribution and vibration modeling. Mining noise-control solutions have been commercialized with external partners and have significantly penetrated the market for sales of the dual-sprocket chain and the drill-bit isolator. In manufacturing and construction, HLP developed noise controls for pneumatic nail-guns and developed the Buy Quiet program to promote engineering noise control in those sectors. HLP Program testing laboratories have remained accredited for several years through the National Voluntary Laboratory Accreditation Program.

In hearing protection, HLP has developed several national and international acoustic-test standards. The Department of Defense has incorporated them into its recently published standard, MIL-STD 1474E [DOD 2015]. The HLP Program has developed new equipment and transitioned it into commercial products. Specifically, HPD Well-Fit™ is not licensed, and it is sold by external partners (Michael & Associates, Custom Protect Ear, Moldex Metric Inc.). In the area of impulse noise assessment, the HLP Program has developed a meter for measuring impulse noise, and the meter is being sold by Structural Dynalysis. The HLP Program is responsible for developing a reliable acoustic-impulse generator that is being sold by BC Precision Tools. It has also developed two acoustic test fixtures, and an acoustic-blast-probe microphone being sold commercially. The HLP Program has worked closely with software developers to enhance the capabilities for acoustic test laboratories—specifically tools (REATMasterPro, the Impulsive Peak Insertion Loss Analyzer [IPILA], and HPDCalc tool) to implement tests according to ANSI and ISO standards.

In best practices for HLP, several key outcomes have been achieved. NIOSH published an extensive review of the status of research in current and emerging areas for occupational hearing loss. The Safe-In-Sound Excellence in Hearing Loss Prevention and Innovation award program is entering its seventh year of identifying companies and individuals in manufacturing, construction, and services sectors that exhibit excellence in HLP. HLP has partnered with the National Hearing Conservation Association (NHCA) and International Journal of Audiology to publish for the past 5 years a supplement in the journal of expanded research papers from the prior year's NHCA conference. These papers highlight hearing loss prevention and promote a global perspective of the field. The HLP Program has developed several topic pages on engineering noise control, Buy Quiet Program implementation, hearing protection, hearing loss prevention, and surveillance. They are available on the CDC/NIOSH website. HLP has participated in the Cochrane Systematic Reviews for occupational hearing loss and effectiveness of hearing protection programs. The

HLP Program has partnered with NHCA, American Automobile Association (AAA), National Safety Council, and Council for Accreditation in Occupational Hearing Conservation (CAOHC) to train hearing conservation professionals for integrating hearing-protector fit testing into HLP programs.

In hearing loss risk factors and epidemiologic research, the HLP Program has advanced understanding of the risks of hearing loss due to impulse and impact-noise exposures. Funded research through the Office of Extramural Programs (OEP) has developed new methods to estimate the risk of occupational hearing loss due to exposures to complex noise, such as continuous and impulsive noise. These methods exhibit promise and can be integrated immediately into standards for measuring workers' noise exposures to better characterize the increased risk when workers are exposed to complex noise. The HLP Program has developed guidance for mixed exposures to chemicals and noise, which was published by the Nordic Experts group. Animal research has advanced understanding of otoprotectants, chemicals that halt programmed cell death (apoptosis) within the cochlea following traumatic noise exposure. Animal research suggests early noise exposure results in neurological deficits that were previously unexplainable.

Immune and Dermal Diseases

Immune and skin-related diseases represent a diverse group of health effects that are common in the workplace. These health effects include asthma, allergic rhinitis, and contact dermatitis. The greatest impact of immune and dermal disease is in the services, agriculture, construction, and manufacturing industries. Workplace exposure to certain chemical substances can lead to contact dermatitis, allergic sensitizations, impaired immune function (including immune suppression and autoimmunity). Exposure can result in uncontrolled inflammation or increased susceptibility to diseases. Workers can be exposed to hazards in various ways, including through inhalation and dermal absorption. A worker's skin can be exposed to hazardous chemicals through direct contact with contaminated surfaces, deposition of aerosols, immersion, or splashes. Skin exposures may cause systemic effects and localized skin injuries. The NIOSH Immune and Dermal Diseases (IMU) Cross-sector Program has a mission to help reduce injury, illness, and death from work-related immune and skin disease. Research priorities are driven by considerations such as surveillance data, stakeholder input, and emerging issues. Significant program activities include identifying immunologic or dermal hazards in the workplace; increasing awareness of occupational exposures to

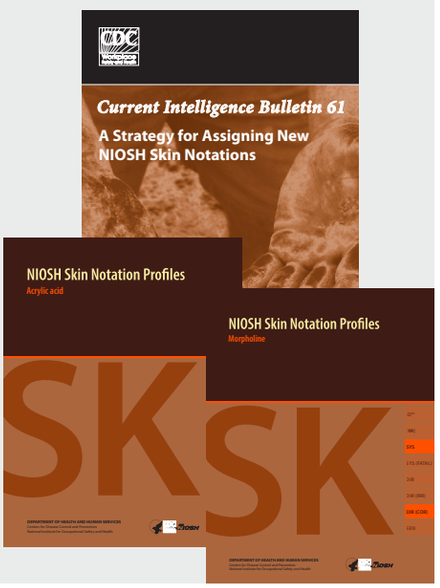
Preventing Skin Diseases with Chemical-Specific Information

Skin diseases account for an estimated 15% to 20% of all reported work-related diseases in the United States. Along with the human suffering, the estimated cost of work-related skin diseases is as high as $1 billion a year.

NIOSH researchers, with about 20 external partners, identified a new way to assign NIOSH Skin Notations to chemicals. NIOSH Skin Notations are hazard warnings used worldwide to alert workers and employers to the health risks of skin exposures to chemicals in the workplace. With each notation, the new system provides a detailed summary of the specific information used to establish the notation for a particular chemical.

To help prevent work-related skin diseases, NIOSH has published more than 40 new Skin Notation Profiles. In addition, NIOSH researchers are developing profiles for more than 120 additional chemicals.

Details: Skin Exposures and Effects



mold and other allergens; developing and publishing new information to characterize occupational chemicals or allergens that cause asthma; identifying and characterizing workplace chemicals that can cause contact or allergic dermatitis and systemic toxicity; and publishing NIOSH Skin Notations to alert workers, employers, risk assessors, and occupational safety and health specialists to the presence of dermal exposure hazards in the workplace.

Further activities during the decade are described below.

- With about 20 external partners participating, the program identified the need for a new, updated means of assigning NIOSH Skin Notations to chemicals. The new system establishes hazard-based notations with accompanying profiles that provide a detailed summary of chemical-specific information used to establish the notation. *NIOSH Current Intelligence Bulletin 61, A Strategy for Assigning New NIOSH Skin Notations* [NIOSH 2011b] and more than 40 Skin Notation Profiles have been published.
- Program research on how nicotine from e-cigarette refill liquids is absorbed through the skin was used by OSHA in a settlement for fines imposed following an investigation of an e-cigarette manufacturing facility.
- Program research on the dermal permeation of perfluorooctanoic acid (used to manufacture Teflon and other perfluorochemicals) was used by the New Jersey Department of Environmental Protection in its dermal risk assessment of ground-water contamination.
- Many Health Hazard Evaluation (HHE) reports have been published, including investigations into outbreaks of contact dermatitis at an ink-manufacturing plant; asthma and respiratory symptoms among workers at a soy-processing plant; cluster of asthma among workers at a chemical-manufacturing plant; sensitization potential of metal-working fluids; and evaluations of biological agents in water-damaged indoor environments.
- The NIOSH bioaerosol sampler was used to detect influenza and has been provided for use at more than 100 agencies and institutions, including the National Aeronautics and Space Administration (NASA).
- Intramural scientists developed a method to quantify chemical allergens in latex and nitrile gloves that was subsequently adopted by ASTM International to help manufacturers assess and lower the allergen levels of their products [ASTM 2014].
- Mold-identification kits, using a patented monoclonal antibody produced by intramural scientists, were developed and marketed by two commercial companies.
- A monoclonal antibody for detecting isocyanates has been developed and used by NIOSH to determine the fate of isocyanates in the skin. This antibody has also been used by academic institutions and the DOW Chemical Company.
- About 220 publications from intramural researchers throughout the decade have addressed program goals. These publications have been cited by others more than 1,800 times.

Musculoskeletal Disorders

Musculoskeletal disorders are among the most-important research issues in terms of frequency and impact across all industry sectors. These disorders are caused by sudden exertion or prolonged exposure to such physical factors as repetition, force, vibration, or awkward postures. Musculoskeletal disorders affect the body's connective tissues (such as muscles, nerves, tendons). The NIOSH cross-sector program for musculoskeletal disorders falls under a program development activity that acknowledges the relevance of key scientific and engineering disciplines that cut across the industry sectors. The program's mission is to reduce the burden of work-related musculoskeletal disorders through research and prevention that protects workers, helps management mitigate related risks and liabilities, and helps practitioners improve the efficacy of workplace interventions.

Many collaborators have participated in the Musculoskeletal Disorders (MSD) Cross-Sector Program over the past decade. About half of the divisions, labs, and offices within the Institute have received or collaborated on MSD-related research projects. Many NORA Sectors have made musculoskeletal

Revised NIOSH Lifting Equation is Widely Used to Prevent Back Injury

Improper lifting is one of the leading causes of work-related back injury and a focus of NIOSH ergonomics research. Ergonomics, the scientific study of fitting the workplace to the worker, helps prevent back and other injuries by designing tasks and work environments to fit employees' physical capabilities and limitations. Using this approach, in the 1980s NIOSH developed the NIOSH Lifting Equation, a formula that calculates the risk of lifting a defined weight in a specific work environment. In 1994, NIOSH revised the equation with international collaborators, who helped adapt the Revised NIOSH Lifting Equation (RNLE) to include composite and variable lifting tasks. Recently, NIOSH modified the tool for pregnant workers.

The RNLE is the most successful ergonomic tool to address manual material-handling issues in the workplace.

The Association of periOperative Registered Nurses (AORN) used the RNLE to develop ergonomic guidelines addressing lifting patients in surgery.

Most U.S. graduate programs in industrial ergonomics or occupational safety and health include the RNLE in their curriculums.

A recent literature review found that 23 of 28 studies comparing risk-assessment methods for identifying low back pain found the RNLE useful in identifying the risk of low back pain in different work populations.

Details: "Evaluation of the Impact of the Revised National Institute for Occupational Safety and Health Lifting Equation" [Lu et al. 2013]

research a priority, including Construction, Healthcare, Manufacturing, Services, and Wholesale and Retail Trade. Federal agency collaborators have included the Occupational Safety and Health Administration, the Department of Defense, the Veterans Administration, and the Transportation Security Administration. State-level collaborators included the Washington State Department of Labor and Industries Safety and Health Achievement Recognition Program (SHARP), and the Ohio Bureau of Workers Compensation. Industry collaborators have included General Motors, Navistar, Toyota, and Whirlpool. Union and labor collaborators include the Center to Protect Workers' Rights, Laborers' International Union of North America, and the Association of periOperative Registered Nurses (AORN). Academic partners have included the University of Cincinnati, The Ohio State University, West Virginia University, the University of Wisconsin—Milwaukee, the University of Utah, the University of Central Florida, and the University of South Florida. International collaborators have come from Italy, Spain, South Korea, and other countries.

The focus of the Musculoskeletal Disorders Cross-sector was redirected in June 2015 to address surveillance, effective ergonomic interventions, and communication dissemination strategic objectives. To that end, the MSD Cross-sector is collaborating with the NIOSH Center for Worker Compensation Studies, the NIOSH Economic Research and Support Office, and the Ohio Bureau of Workers Compensation.

In 2005, the Revised NIOSH Lifting Equation (RNLE) was found to be the ergonomic assessment tool used most often (83.1%) by Certified Professional Ergonomists (CPE). This tool, created in the 1980s and revised in the 1990s, remains the most-successful ergonomic tool to address manual material-handling issues in the workplace. Collaborators from Spain and Italy have modified the analysis technique to allow for considering composite and variable lifting tasks. The tool has been incorporated into ISO Standard 11228-1:2003—Manual Handling—Part 1 [ISO 2003]. AORN used the revised lifting equation to develop ergonomic guidelines to address patient-lifting, or lifting parts of patients in surgery settings. Recently the revised lifting equation was modified to address the stress and strain on pregnant workers performing manual material-handling tasks.

Other NIOSH MSD research has addressed exposure to either hand-arm or whole-body vibration. Results were presented at the Sixth American Conference on Human Vibration held in 2016. Several research projects with the Department of Defense have focused on using vibrating power tools, such as riveting tools and grinders.

Respiratory Diseases

Work-related respiratory diseases occur in all industry sectors and can affect any part of the respiratory tract, from the nose to the deep lung. Disease onset can occur immediately after an exposure, or decades later. Work-related respiratory diseases are often chronic and can lead to disability or death.

The NIOSH Respiratory Diseases Research (RDR) Cross-sector Program works to provide national and international leadership to prevent work-related respiratory diseases. The program fosters communication, collaboration, and coordination of efforts across the many disciplines and parts of NIOSH that work to achieve this goal. The program uses a scientific approach to gather and synthesize information, create knowledge, provide recommendations, and deliver products and services to those who can impact prevention. Working with other NIOSH programs, the RDR Program has made essential contributions to occupational respiratory disease surveillance, basic research in determining how exposures cause disease, and a range of areas critical to disease prevention, such as epidemiology, exposure assessment, engineering controls, respiratory protection, training, and authoritative recommendations. The program provides unique national resources in the areas of lung-function testing and X-ray surveillance for lung disease.

The Respiratory Diseases Research Program has had useful and productive partnerships with intramural and extramural partners. Intramural partners have represented multiple parts of NIOSH and CDC. Examples of extramural partners include labor unions, industry, academia, government agencies, and professional organizations.

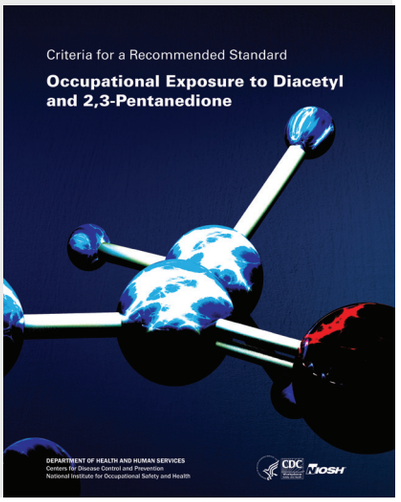
NIOSH Identifies New Exposures for Irreversible Lung Disease

In the past decade, NIOSH research found that flavoring-related lung disease, commonly called popcorn lung because of its association with microwave-popcorn production, also occurs among workers in flavoring manufacturing and coffee processing. The occupational disease causes irreversible lung damage documented in some workers who have had lung biopsies due to obliterative bronchiolitis. Using lung-function test spirometry, NIOSH research identified several types of lung function abnormalities in affected workers, not just the obstructive abnormalities originally described. Follow up of microwave popcorn production workers showed excess risk for dying from a category of lung disease potentially related to flavoring exposure. NIOSH investigations of the disease's toxicological mechanisms confirmed the causative role of the artificial flavoring diacetyl and showed that inhaling a similar chemical and diacetyl substitute called 2,3-pentanedione had similar toxic effects on lung function. Based on these studies, NIOSH recommended reducing exposures to diacetyl and 2,3-pentanedione to prevent flavoring-related lung disease. These recommendations were outlined in the NIOSH publication, *Criteria for a Recommended Standard: Occupational Exposures to Diacetyl and 2.3-Pentanedione*.

NIOSH research motivated prevention efforts in work settings and beyond:

- California developed regulations to protect workers.
- The Occupational Safety and Health Administration enforced worker protections.
- The Food and Drug Administration is examining the potential risk associated with flavorings in electronic cigarettes.

Details: Flavorings-related Lung Disease



A comprehensive review of the RDR Program by the National Academy of Sciences was conducted early in NORA's second decade. Guidance about priorities for future work gleaned from the review was used to identify and focus on five highest priorities for the decade: occupational respiratory disease surveillance, digital chest radiography, flavorings-related lung disease, work-related chronic obstructive pulmonary disease (COPD), and work-related asthma.

Occupational respiratory disease surveillance: Surveillance plays a critical role in setting priorities and tracking progress. Surveillance is especially challenging for occupational respiratory disease, which may occur long after causative exposures and is often attributed to causes other than work. RDR Program surveillance helped to motivate MSHA's Respirable Coal Mine Dust Rule in 2014 [Lowering miners' exposure to respirable coal mine dust (CFR) 2014] and was cited by OSHA in its Silica Rule finalized in 2016 [OSHA 2016] and by stakeholders both in favor and opposed to the Silica Rule. The RDR Program has helped states develop and report on the burden of pneumoconiosis and work-related asthma. The RDR Program also helped states communicate silicosis risk in workers employed in the engineered countertop industry, which led to recognizing the first U.S. case. Sentinel surveillance through the Health Hazard Evaluations Program led to recognizing novel occupational respiratory diseases, such as flavoring-related lung diseases in new settings and indium-related lung diseases, including alveolar proteinosis. The RDR Program partnered with others in NIOSH to improve surveillance for work-related diseases by including analyzable industry and occupation information in electronic health records. Inclusion has been presented for public comment by the Office of the National Coordinator for Health Information Technology.

Digital chest radiography: Early in the decade, digital chest radiography had almost entirely replaced analog film-based chest radiography in clinical settings, but occupational screening programs continued to require outdated film technology. RDR Program research documented how digital chest radiography could be substituted without affecting screening outcomes. Based on this research, the International Labour Organization updated its system for classifying chest radiographs, and both NIOSH and the Department of Labor were able to update regulations to allow use of modern technology.

Flavorings-related lung disease—The RDR Program identified this disease in microwave popcorn production workers during NORA's first decade. In the second decade, flavorings-related lung disease was identified in new settings, including flavoring manufacturing and coffee processing. The spectrum of lung function abnormalities associated with the disease was widened from obstructive to restrictive, along with mixed patterns of impairment. Investigation of toxicological mechanisms confirmed the role of diacetyl and showed that inhaling related alpha-diketones also used as food flavorings, such as 2,3-pentandione, had similar respiratory toxicity. The effectiveness of preventing illness through reducing exposure was documented. RDR Program research motivated prevention efforts by industry, California's development of regulations to protect workers, and OSHA enforcement activities.

Work-related COPD—About 15 million people in the United States have chronic obstructive pulmonary disease (COPD), with about 15% of cases attributable to work. Direct medical costs for work-related COPD cases alone were about $4 billion in 2007. In part due to RDR Program research and surveillance, MSHA mandated periodic spirometry to screen coal miners for COPD, and OSHA mandated periodic spirometry to screen silica-exposed workers for COPD. Because of its critical role in identifying COPD, the RDR Program has focused much effort on improving the quality of spirometry. About 30 organizations offer RDR Program-certified spirometry courses with about 2,500 students completing training each year. RDR Program educational materials, such as the poster, "Get Valid Spirometry Results Every Time" [NIOSH 2011a], are popular, with more than 90,000 copies distributed worldwide, and manufacturers of spirometers including copies with their products. RDR Program research on using longitudinal spirometry for early recognition of COPD and other respiratory diseases was used by the American Thoracic Society in its technical standards for occupational spirometry.

Work-related asthma—About 9.6 million adults in the United States have had an asthma attack in

the previous 12 months, with about 15% of cases attributable to work. The direct medical costs for work-related asthma cases alone were about $2.3 billion in 2007, with total costs much greater. RDR Program work calling attention to work-related asthma helped to motivate action by others. The U.S. Department of Health and Human Services (DHHS) adopted a Healthy People 2020 goal on adults with asthma, discussing work-relatedness with healthcare providers. States implemented a new surveillance measure on asthma caused or made worse by work. OSHA implemented a national emphasis program on isocyanates. RDR Program research contributed to acceptance that indoor dampness and mold is a risk factor not only for making asthma worse, but also for developing new asthma. RDR Program research has improved understanding of how isocyanate-induced asthma occurs and led to developing monoclonal anti-isocyanate monoclonal antibodies, which are promising tools for biomarker development.

Traumatic Injury

Traumatic injuries have always plagued workers. Today, work-related injury and death from traumatic injuries resulting from such things as workplace violence, falls, contact with industrial objects and equipment, and motor-vehicle crashes continue to claim lives, damage physical and psychological well-being, and consume the resources of workers and their families. In order to prevent traumatic occupational injuries among the entire U.S. workforce, NIOSH has a focused program of surveillance, high-quality research, and effective translation through collaboration, and practical prevention measures. Research priorities of the Traumatic Injury (TRI) Cross-sector Program are driven by available injury and fatality data. TRI Program research and prevention efforts target sectors with high risk of traumatic injuries, including agriculture, construction, and transportation. Priority areas address increasing surveillance to guide research and prevention; reducing traumatic injuries from falls, motor-vehicle incidents, workplace violence, industrial machines, and vehicles; and better understanding the risks and injuries occurring among high risk and vulnerable workers. The program uses a traditional public health model as its research framework involving surveillance, risk-factor identification, prevention strategy and technology development, intervention evaluation, and information dissemination to its audience.

The Traumatic Injury Cross-Sector Program works to reduce the incidence of traumatic occupational injuries and deaths through a focused program of surveillance, research, and prevention. The program is directed by a multidisciplinary steering committee with members from most NIOSH research divisions and the Office of Extramural Programs, ensuring that the program is reflective of the breadth and richness of NIOSH expertise, and encompasses extramural research. The program has strong working relationships and overlapping goals with NIOSH sector-based programs that have high injury rates (such as Mining, Agriculture, and Construction). The steering committee revised the program's strategic goals in May 2014, after review and input from extramural researchers, professional associations, worker safety organizations, and government agencies. Partnerships range from the programmatic to the individual project level. Partners include federal agencies, state surveillance programs, unions, trade organizations, private-sector manufacturers, individual employers, research organizations, and professional associations. In NORA's second decade, the program and its partners cosponsored three National Occupational Injury Research Symposia to bring intramural and extramural researchers together to present their latest research studies, methods, and findings; and to network and develop research collaborations.

Partnerships have been critical in ensuring the relevance of the program's research, and in translating that research into practice. The program looks forward to expanding its partnership base in the next decade and continuing to advance worker safety through impactful science.

The program has made progress on each of its six strategic goals, and it has many examples of research being translated into practice for improved worker safety. Noteworthy examples include the following:

- The NIOSH Ladder Safety smartphone app, the first of its kind within NIOSH, was downloaded more than 96,000 times through August 2016. The app incorporates NIOSH

science and a patented device to quickly establish a safe ladder angle. (Strategic goals: Fall Prevention, High-risk and Vulnerable Workers).

- The program has partnered with federal agencies, including the Department for Homeland Security, along with private sector partners, to develop science-based standards to improve the crashworthiness of ambulances. (Strategic goals: Motor Vehicle Safety, and High-risk and Vulnerable Workers)
- Nearly 20,000 healthcare professionals completed the free NIOSH online violence prevention course for nurses through August 2016. This course, developed in partnership with extramural researchers and federal partners, built upon previous research illustrating that nurses were infrequently trained on their risk for workplace violence and prevention measures. (Strategic goals: Workplace Violence Prevention, High-risk and Vulnerable Workers)
- The webpage with NIOSH-designed Cost-effective Rollover Protective Structure (CROPS) designs for tractors has been visited nearly 20,000 times through June 2016. These designs can be used by manufacturers or by individual farmers to retrofit older tractors with life-saving Rollover Protective Structures (ROPS) that are less expensive than those available from manufacturers and dealers. The CROPS designs and website complement efforts by NIOSH-supported agricultural centers to increase the use of ROPS on tractors. (Strategic goals: Machine and Industrial Vehicle Safety, High-risk and Vulnerable Workers)
- Fire fighter research activities, including fatality investigations and collection of anthropometric data, led to changes in consensus standards for Self-Contained Breathing Apparatus, building codes to mark homes using manufactured trusses, municipal ordinances to mark hazardous structures, and seat belt designs to better accommodate fire fighters in gear (Strategic goals: Surveillance, High-risk and Vulnerable Workers)

Along with the impacts identified above, the number of visits to program webpages demonstrates widespread use of research by stakeholders. In 2015, more than 787,000 such visits occurred.

Partnerships have been critical to ensuring the relevance of the program's research, and also to translating that research into practice. The program looks forward to expanding its partnership base in the next decade and continuing to advance worker safety through impactful science.

Ladder App Has Far-Reaching Effects

In many workplaces, falls are a persistent hazard, and one of the main causes is improper ladder use. More than 600 workers died and nearly 213,000 suffered critical injuries from falls, according to 2009 data from the U.S. Bureau of Labor Statistics.

To help workers use extension ladders more safely, NIOSH released its first smartphone app in 2013. With more than 96,000 downloads since then, the Ladder Safety App continues to help improve the safety of workers using extension ladders. The app incorporates NIOSH science and patented technology to quickly establish a safe ladder angle. Along with this ladder-positioning tool, the Ladder Safety app contains general ladder safety, inspection, and selection guidelines, as well as accessory information. In 2015, the app extended to include safety information for stepladder users. Based on existing ladder-safety standards and regulations, the new stepladder module provides easy-to-use, graphic-oriented safety tools, checklists, and guidelines. The Ladder Safety app is available free, in English or Spanish, for Apple and Android smartphones.

Since its release in 2013, the Ladder Safety app has helped thousands of users set up and use extension ladders more safely to prevent falls.

Details: Falls in the Workplace

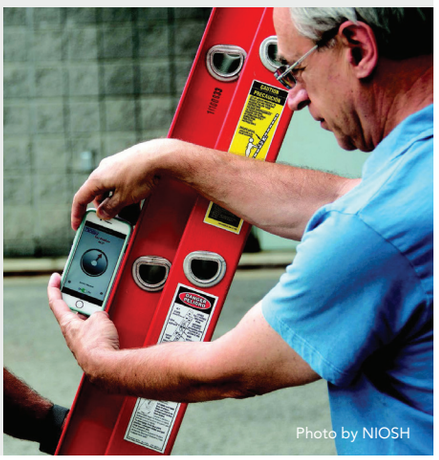


Photo by NIOSH

Work Organization and Stress-Related Disorders

Work organization and job stress are growing concerns in all industries. Job stress results from poor work organization, such as when job demands outweigh the capabilities, resources, or needs of workers. Research has linked stress at work to lost productivity, workplace injury, and serious health outcomes, such as depression and heart disease. A steering committee representing NIOSH divisions and offices guides the Work Organization and Stress-Related Disorders (WSD) Cross-sector Program. The program promotes safety and protects worker health. This is done through research to understand work organization risk and protective factors related to stress, illness, and injury in the workplace. The program encompasses a wide range of research, which includes exploring how changing organizational practices influence risk factors for job stress and other hazardous exposures; understanding how workplace stress contributes to illness, injury, and disease development at work; identifying effective multilevel intervention strategies to prevent stress at work; understanding the socioeconomic cost and burden of job stress; developing improved methods and tools for job stress research; and investigating stress in understudied populations.

The structure of NORA's second decade brought the Work Organization and Stress Disorders (WSD) Program together. Because of this new structure, the program was able to develop a healthy network of internal and external partners and accomplish a variety of high-quality activities that brought visibility to work organization and stress science, and it facilitated knowledge transfer to a diverse stakeholder audience.

During NORA's second decade, the WSD Program worked with NIOSH DLOs and other NIOSH Cross-sector Programs. External partners included academia, professional associations, research organizations, organized labor, and other government entities, as well as international partners.

Further program activities during the decade are listed below.

- Conferences—Work, Stress, and Health (WSH) 2006, 2008, 2009, 2011, 2013, 2015 (see Work, Stress, and Health 2017: Contemporary Challenges and Opportunities); WSD-organized sessions of NIOSH research program posters for WSH 2008, 2009, 2011, 2013, 2015.
- NIOSH web-based outputs—Workplace Safety and Women Podcast (2009); Work Organization Measures Inventory (2008); Violence Against Nurses Training (2013); Emergency Responder Long Work Hours Training (2014); Shift Work and Long Work Hours for Nurses Training (2015).
- External webinars—Intervening for Work Stress (cosponsored with TWH, 2014) [Hammer and Ganster 2014].
- Internal seminars—Occupational Stress Research (2007); Work Organization and Health (2007); Safety Engagement and Occupational Safety and Health (2010); Occupational Health Psychology (2012); Canadian Mental Health Standard (2014); NIOSH Science Forum on stress (2014).
- Social media—regular activity on LinkedIn group and Twitter feed (2013 to present); U.S. News Twitter Chat on Sleep Health expert participant [Haupt 2013]; Total Worker Health® Twitter Chat on Stress expert participant (2013).

NIOSH Science Blog Articles—Workplace Stress (2007); Police and Stress (2008); Horrible Bosses: Workplace Violence in the Real World (2011); Sleep and Work (2012); NIOSH Research on Work Schedules and Work-related Sleep Loss (2012); Stress and Health in Law Enforcement (2012); Women's Health at Work (2013); Intervening for Work Stress (2014); What Works Best to Prevent Stress Among Healthcare Workers: Changing the Organization or Educating Staff? (2014); Work, Stress, and Health: Help Us Plan the Next 25 Years (2015).

- National surveillance—General Social Survey modules, Quality of WorkLife Questionnaire (2002, 2006, 2010, 2014); Violence in the Workplace (2004, 2012).
- Refereed publications—More than 100 journal articles and NIOSH-numbered publications; program-based article in Society for Occupational Health Psychology (SOHP) newsletter (2010).
- Working groups and meetings—NIOSH/Labor meeting (2007); WSD Stakeholders meeting

NIOSH Addresses Workplace Stress through Research and Education

Stress—the "health epidemic of the 21st century," according to the World Health Organization—is a primary focus of research and education at NIOSH. Drawing from national surveillance data from the NIOSH Quality of WorkLife Questionnaire, administered in 2006, 2010, and 2014, NIOSH researchers coauthored more than 100 peer-reviewed publications and webpages addressing job stress. They also cosponsored six international conferences on workplace stress, which brought global experts together to share critical research and identify emerging priorities for stress science. To reach both technical and lay audiences, researchers disseminated research findings and evidence-based recommendations through social media, blogs, podcasts, webinars, and online training modules.

To date, more than 16,000 nurses and nurse managers have accessed the NIOSH Training for Nurses on Shift Work and Long Work Hours [NIOSH 2015c] via computer or mobile device. NIOSH investigations of job stressors for older workers helped spur the development of NIOSH's National Center for Productive Aging and Work, which actively engages in collaborative, age-related research and develops resources to promote and facilitate aging-friendly workplaces. Collectively, the stress-related articles posted on the NIOSH Science Blog received more than 38,000 views since 2011. NIOSH topic pages on stress have received nearly 300,000 views since 2010, and the Stress at Work topic page continues to be a popular public resource, receiving more than 23,000 views in 2015 alone.

Details: Stress at Work, and Productive Aging and Work

Photo by Thinkstock

(2008); NIOSH Safety Climate Working Group (2013 to present).

- In-process activities (through end of decade)—editing book from Work, Stress, and Health 2015 conference; updating "Stress … at Work" [NIOSH 1999a]; preparing for Quality of WorkLife 2018 module.

Authoritative Recommendations

External stakeholders within industry, labor, professional associations, and other government agencies use NIOSH recommendations to protect workers from injury, illness and death. Functions of the NIOSH Authoritative Recommendations (AUR) Cross-sector Program include scientifically assessing workplace risks and hazards; developing, disseminating and evaluating recommendations; providing responses to other government agencies on issues of rule-making that may affect workers; and managing the NIOSH respirator certification program. NIOSH develops several types of authoritative recommendations. The most recognized include recommended exposure limits, immediately dangerous to life or health (IDLH) values and respirator certifications. NIOSH bases its recommendations on comprehensive evaluations of available scientific data, which might include exposure-response modeling or quantitative risk assessment.

The Authoritative Recommendations Program of the NIOSH Program Portfolio includes activities involved in the scientific assessment, development, dissemination, and diffusion of NIOSH authoritative recommendations for assuring safe and healthy working conditions for all workers. The Authoritative Recommendations Program coordinates and facilitates developing and disseminating NIOSH occupational safety and health guidance. The priorities of the program are driven by OSHA and MSHA requests, the stated goals of the sector and cross-sector programs, and requests from labor and industry partners. These recommendations cross all industry sectors, all occupations, and encompass occupational hazards faced by all workers. External partners include those agencies and organizations that are either recipients, influenced by, or otherwise impacted by NIOSH authoritative recommendations focused on occupational safety and health. Among these partners are the following:

- Occupational Safety and Health Administration (OSHA) and Mine Safety and Health Administration (MSHA), Department of Labor (DOL)
- Environmental Protection Agency (EPA)
- World Health Organization (WHO)
- American Industrial Hygiene Association (AIHA)
- Representatives from organized labor and industry groups
- Academic research institutions.

The Authoritative Recommendations Program focuses on providing guidance through the following priority goal activities:

- Developing 10 manuscripts with NIOSH and stakeholder authors for a dedicated peer-reviewed journal that addresses the state-of-the-science of risk assessment and occupational hygiene as it impacts occupational exposure limits.
- Partnering with AIHA, OSHA, and others to develop and promote a strategy with guidance for performing health-hazard banding to assess chemical hazards.
- Assessing and establishing a policy for classifying chemical hazards as occupational carcinogens and setting exposure limits for these hazards.

For the 5-year period from 2006 through 2011, on average 12 *Federal Register* notices were published per year in which other agencies cited NIOSH recommendations and guidance.

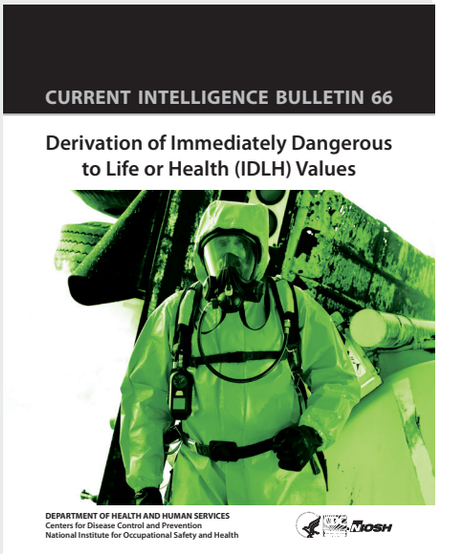
- In FY2011, other agencies cited NIOSH recommendations and guidance in 21 Federal Register notices.
- In FY2012, other agencies cited NIOSH recommendations and guidance in 23 Federal Register notices.
- In FY2013, other agencies cited NIOSH recommendations and guidance in 16 Federal Register notices.
- In FY2014, NIOSH had 33 policy response activities; NIOSH recommendations were used by 23 agencies such as OSHA, EPA, and MSHA.
- In FY2015, NIOSH had 42 policy response activities through June 2015; NIOSH recom-

Authoritative Recommendations Help Assure a Safe, Healthy Workplace

At NIOSH, assuring safe and healthy working conditions for all workers depends, in part, upon the Authoritative Recommendations Program. Through this program, NIOSH publishes guidance for workplace safety and health based on current research findings. This guidance helps inform policy makers, occupational safety and health professionals, employers, and workers about how to stay safe and healthy on the job.

In fiscal year 2014, NIOSH participated in 33 activities related to policy response, typically by commenting and providing recommendations on other agencies' proposed regulations or giving testimony in public rulemaking hearings. NIOSH recommendations informed 23 agencies, including the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), and the Mine Safety and Health Administration (MSHA). The following year, these numbers increased, with NIOSH providing recommendations that agencies used in at least 25 instances. Overall, NIOSH participated in 42 policy-response activities.

NIOSH also established the scientific basis for describing the effects of specific chemical exposures in the workplace as Immediately Dangerous to Life or Health (IDLH) values. This work now paves the way for NIOSH researchers to develop IDLH values for additional chemicals.



Details: Current Intelligence Bulletin 66: Derivation of Immediately Dangerous to Life or Health (IDLH) Values

mendations were cited or used in at least 25 instances by agencies and institutes, such as OSHA, EPA, and MSHA.

Since 1998, NIOSH has developed publications with authoritative recommendations and guidance, including recommended exposure limits (RELs), on a variety of hazardous workplace exposures. Examples of these include the following:

- Criteria for a Recommended Standard: Occupational Exposure to Metalworking Fluids (1998)
- NIOSH Hazard Review: Carbonless Copy Paper (2001)
- NIOSH Hazard Review: Health Effects of Occupational Exposure to Respirable Crystalline Silica (2002)
- Criteria for a Recommended Standard: Occupational Exposure to Refractory Ceramic Fibers (2006)
- Current Intelligence Bulletin 62: Asbestos Fibers and Other Elongate Mineral Particles: State of the Science and Roadmap for Research (Revised April 2011)
- Current Intelligence Bulletin 63: Occupational Exposure to Titanium Dioxide (2011)
- Current Intelligence Bulletin 65: Occupational Exposure to Carbon Nanotubes and Nanofibers (2013)
- Criteria for a Recommended Standard: Occupational Exposure to Hexavalent Chromium (2013)

NIOSH has also developed publications that establish the scientific basis for deriving skin notation profiles and Immediately Dangerous to Life or Health (IDLH) values for specific chemical hazards in the workplace. Subsequently, NIOSH is developing skin notation profiles and IDLH values for more than 150 chemicals, each using the guidance and strategies described in the following publications:

- Current Intelligence Bulletin 61: A Strategy for Assigning New NIOSH Skin Notations (2009)
- Current Intelligence Bulletin 66: Derivation of Immediately Dangerous to Life or Health (IDLH) Values (2014)

Along with the IDLH values and skin notation profiles, NIOSH continues to assess workplace hazards and develop guidance in the form of criteria documents, current intelligence bulletins, hazard reviews, and NIOSH Alert publications. Among the specific topics NIOSH is evaluating, with the intent of developing guidance in the form of these publications, are occupational exposure to heat and hot environments; diacetyl and 2,3-pentanedione; 1-bromopropane; toluene diisocyanates; glutaraldehyde; diethanolamine; and manganese in welding fume.

Economics

Applying economics in occupational safety and health gives a framework to identify economic inefficiencies associated with poor safety and health, and it points to prevention opportunities with the greatest impact and value. NIOSH studies economic factors influencing the incidence and severity of work-related injury or illness. Also researched are the costs of injury and illness for workers, employers, and society overall. This work gives guidance for how to best allocate limited resources in occupational safety and health. Priority research efforts for the NIOSH Economics (ECN) Cross-sector Program include studying economic factors that may affect work organization and in turn affect injury or illness rates, estimating the economic impact of injury and illness on small businesses, and understanding how injuries and illnesses that are only partially paid—or missed entirely—by workers' compensation contribute to the cost of programs, such as short-term disability and group medical insurance.

Internal partners included a core team of doctoral-level economists, as well others with an interest in economics. These included those who focus on workers' compensation, work organization and stress, musculoskeletal disorders, surveillance, occupational health disparities, and total worker health. Some sector partners included economists in their steering committees or requested technical assistance from economists. External partners included economists from other parts of CDC and other government agencies, as well as stakeholders from academia, workers' compensation insurance and professional organizations, and the private sector. Many external partners take interest in economic factors that affect the incidence and severity

Making the Case for Paid Sick Leave

Improving our understanding of how economic factors, management strategies, and demographic trends affect worker safety and health will help the private and public sectors identify workplaces where these conditions need to be altered or their effects mitigated.

In 2012, a pioneering NIOSH study reported that workers with access to paid sick leave were 28% less likely to suffer nonfatal occupational injuries than workers without access to paid sick leave. These findings suggest that giving employees paid sick leave might help employers reduce the incidence and, subsequently, the cost, of occupational injuries. Paid sick leave can also decrease other risks and costs related to sick workers, such as spread of contagious diseases to coworkers. Despite the potential benefits for employers offering paid sick leave, 43% of American private-sector workers reported not having access to this fringe benefit during the study period. The findings were disseminated and reported widely, including major media coverage in the *New York Times* and other news outlets.

Details: Making the Case for Paid Sick Leave

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of worker injury and illness, the broad economic consequences of worker injury and illness, and the value of prevention.

In the second NORA decade, the ECN Program expanded from just addressing the economic and social consequences of occupational injury and illness to also addressing economic factors affecting worker injury and illness. The more holistic approach to worker injury and illness adopted in the second NORA decade also helped to expand the program's focus. An example of how this benefited understanding of worker safety and health was the overwhelmingly positive stakeholder response to the program's work on paid sick leave.

Examples of the program's contributions include published research on important policy areas, such as the effect of paid sick leave on the incidence of occupational injury, the effect of workplace bullying on absenteeism and health-related quality of life, and the often-neglected additional burden of occupational injury on injured workers and their family members. This burden manifests as comorbidities suffered by injured workers, and increased hospitalizations and musculoskeletal disorders suffered by family members. Research has also studied how to use group health insurance claims to help assess the burden of worker injury and illness. As it moves science into practice, the program is completing its findings, based on applied research conducted directly with employers in the sectors, on the business value of specific safety and health interventions. Descriptions of these activities are also available through the program's website. The increasing importance of economics for NIOSH and its stakeholders was recognized when NIOSH established the Economics Research and Support Office (ERSO) in the Office of the NIOSH Director in October 2014. ERSO serves as central focus for economic research, analysis, and support for all NIOSH divisions, laboratories, and offices (DLO). Along with addressing program goals, ERSO activities include evaluating the economic impact of NIOSH programs and recommendations, supporting division, lab, or office program and project activities, and developing training materials and training to promote using economic metrics.

Emergency Preparedness and Response

Along with their routine work duties, emergency responders face more hazards when they respond to disasters or novel events, such as infectious disease outbreaks, natural disasters, major hazardous materials emergencies, and terrorism response. Sometimes significant health consequences of other potential hazards are not well understood at the time of an event, such as in terrorist attacks involving biological or chemical weapons. Emergency response work includes activities involving search, rescue, recovery, cleanup, and restoration. It is

Protecting Workers Who Protect Us: Emergency Responder Health Monitoring and Surveillance System

During a disaster or novel event, we depend on emergency responders to protect our health and safety. At the same time, emergency responders also need protection from the health and safety hazards that they may encounter in the line of duty. To provide a framework for protecting the health and safety of first responders, NIOSH worked with the U.S. National Response Team (NRT), other federal agencies, state health departments, labor unions, and volunteer emergency-responder groups to develop the Emergency Responder Health Monitoring and Surveillance (ERHMS) System. Based on observations of health effects in first responders to the attacks of September 11, 2001, ERHMS provides a framework and useful tools to guide organizations on how to protect responders before, during, and after an emergency.

Although a NIOSH publication, "Emergency Responder Health Monitoring and Surveillance: NRT Technical Assistance Document" was still under development, many ERHMS concepts were implemented to inform measures to reduce the risk for injury and illness to responders and volunteers during response and clean-up efforts stemming from the 2010 Deepwater Horizon oil spill in the Gulf of Mexico. Since then, the National Response Team adopted the publication as a Technical Assistance Document. NIOSH continues to work closely with CDC to implement aspects of the document to prepare CDC staff to respond to emergencies, including Ebola.

Details: Emergency Responder Health Monitoring and Surveillance (ERHMS)


Photo by Thinkstock

carried out, for example, by individuals from emergency management, fire services, law enforcement, emergency medical services, public health, construction and other skilled support, disaster relief, mental health, and volunteer organizations. The NIOSH Emergency Preparedness and Response (EPR) Cross-sector Program was developed to advance research and collaborations to protect the safety and health of emergency-response providers and recovery workers. The current research priorities of this program are based on lessons learned from past disaster responses, feedback received from government and nongovernment stakeholders during a public meeting held by NIOSH, and from a Federal Register Notice Request for Information. Priority areas address safety climate, personal protective equipment, surveillance, hazard characterization, technological interventions and engineering controls, environmental microbiology, and biological monitoring of terrorism agents.

Engineering Controls

Engineering control of work-related hazards is a continually developing field because of changes in the workplace. Engineering controls are used to remove workplace hazards or lessen the negative effective of exposure to them. In recent years, the emerging threat of terrorism has blurred the line between controls to protect workers and controls to protect public health. During NORA's second decade, research on engineering controls was conducted by NIOSH programs that include Construction, Healthcare and Social Assistance, Hearing Loss, Manufacturing, Mining, Nanotechnology, Prevention through Design, and Services. Traditionally, a hierarchy of controls has been used as a way to determine how to implement feasible and effective control solutions. Efforts of the Engineering Controls (ENG) Cross-sector Program include promoting, planning, and conducting research on engineering control technology; providing expertise in formulating effective and credible workplace standards; and consulting on how to apply effective control solutions and techniques to prevent hazards. Efforts may also include providing resources and information necessary to protect the safety and health of workers during public health emergency-response activities. Regulatory agencies, such as OSHA, use NIOSH engineering control research for their regulatory and enforcement activities.

The ENG Program has involved intramural participants from nearly all divisions at NIOSH. The program has supported projects involving extramural participants from labor, industry, government, academia, and many industry and trade associations.

Highlights of the ENG cross-sector's activities and outcomes are listed below.

- A priority goal of the ENG Program was promoting engineering controls for silica. The Silica/Asphalt Milling Machine Partnership was a highlight of ENG cross-sector activities and addressed goals of controlling silica dust exposures. Because of this project, all United States and foreign milling machine manufacturers that sell pavement-milling machines to the U.S. market signed letters certifying that they will have NIOSH-evaluated silica engineering controls on all new milling machines by January 2017. The top two manufacturers, covering 80% of the U.S. market, started putting engineering controls for silica dust on new milling machines in 2014, 3 years ahead of the 2017 agreed-upon deadline. The research met several cross-sector goals and resulted in a publication, Control Worker Exposure to Respirable Crystalline Silica During Asphalt Pavement Milling.
- OSHA and NIOSH issued a Hazard Alert, "Worker Exposure to Silica during Countertop Manufacturing, Finishing and Installation." It contained recommended steps for assessing and controlling worker exposure to silica dust.
- Another NIOSH engineering control silica project found that connecting a regular shop vacuum to a dust-collecting circular saw reduces silica dust by 80% when cutting fiber-cement siding. This research meets ENG Program silica goals. The findings and recommendations were published in a NIOSH Workplace Solutions publication, "Reducing Hazardous Dust Exposure When Cutting Fiber-Cement Siding."
- A recent NIOSH publication addresses ENG Program goals to control exposures to diacetyl using best practices for engineering controls recommended by NIOSH. The publication, published in 2015, is "Best Practices: Engineering Controls, Work Practices, and Exposure Monitoring for Occupational Exposures to Diacetyl and 2,3-Pentanedione."
- Engineering control research on methylene chloride hazards for bathtub refinishers resulted in a NIOSH and OSHA joint Hazard Alert, "Methylene Chloride Hazards for Bathtub Refinishers."

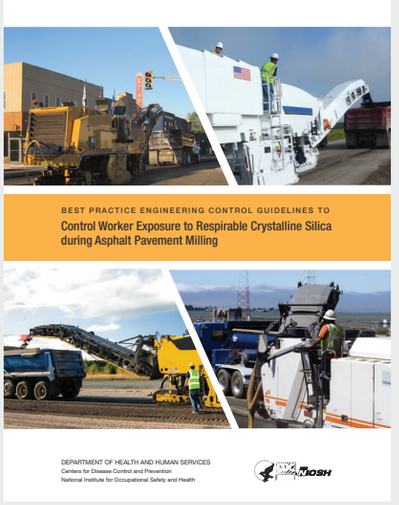
Manufacturers Adopt Dust Controls for New Asphalt Cold Milling Machines

In 2014, nearly 300,000 U.S. employees worked in highway, street, and bridge construction—many on pavement milling tasks that can release airborne dust containing respirable crystalline silica. Occupational exposures to silica dust are associated with risks for serious lung diseases, including silicosis and cancer.

To protect these workers, NIOSH worked with partners to modify asphalt cold milling machines, which workers use to grind pavement for recycling. Led by the National Asphalt Pavement Association (NAPA), the decade-long partnership of private contractors, unions, and government agencies developed dust controls to limit silica dust to levels that are below recommended limits.

All manufacturers selling asphalt cold milling machines in the United States made a commitment that all new milling machines will, by 2017, have dust controls to maintain silica hazards at levels below occupational exposure limits.

Details: Best Practice Engineering Control Guidelines to Control Worker Exposure to Respirable Crystalline Silica During Asphalt Pavement Milling.



- An OSHA-NIOSH Hazard Alert, "Worker Exposure to Silica during Hydraulic Fracturing," was issued and a patent is pending on a NIOSH mini bag-house design to control silica dust during hydraulic fracturing. The engineering control is in the final stages of development and testing .
- A publication on engineering controls for nanomaterial production and downstream handling processes, Nanomaterial Production and Downstream Handling Processes, was published as a result of a project funded by the ENG Program. The publication has been widely used by nanomaterial manufacturers to develop and implement engineering controls at U.S. nanomaterial manufacturing facilities.
- The ENG Program has developed commercialized engineering controls for noise in mining. For example, the dual sprocket chain for the continuous mining machine and drill bit isolator are both commercially available and used in the field.
- The first NIOSH smartphone application, Ladder Safety, offers a set of tools to help with using extension ladders safely. The app was downloaded more than 96,000 times by the end of August 2016.
- The NIOSH guardrail system developed by DSR researchers is now commercially available, and in two separate occasions it has prevented a worker from falling 20 feet to concrete surfaces.
- The NIOSH Health Hazard Evaluation (HHE) Program conducted five HHEs on electric and magnetic field exposures in the workplace. Two of these HHE reports evaluated the National Institute of Standards and Technology's atomic clock signal projection and relay systems and provided recommendations to reduce worker exposures. Collaborative efforts between NIOSH and the Center for Construction Research and Training (CPWR) continued throughout the decade, resulting in the annual CPWR/NIOSH Engineering Controls in Construction Workshop. These workshops spurred new research and helped disseminate other research findings.

Exposure Assessment

The workplace can present many health hazards and exposures that can lead to illnesses and injuries that cause disability, death, and immense costs to society. Efforts of the Exposure Assessment (EXA) Cross-sector Program promote using exposure assessment to identify and characterize workplace hazards. Exposure assessment prevents disease by making it possible to anticipate, recognize, evaluate, control, and confirm hazardous exposures and measures designed to protect against them. The NIOSH EXA Program provides national and international leadership for developing and using effective exposure assessment tools. Expanded use of these tools has led to cost-effective environmental determinations, including which workers are exposed to hazards, routes of exposure, extent, frequency, and duration of exposure, and the effectiveness of interventions. Program priorities include fostering research and giving guidance to develop or improve exposure assessment strategies. Also a priority is developing or improving specific tools to assess worker exposures to critical occupational agents and stressors. The EXA Program works to increase visibility and coordination of exposure assessment throughout NIOSH and across a broad spectrum of government, industry, labor, academic, and international partnerships. The program accomplishes this through intramural and extramural activities.

The EXA Program gives national and international leadership for developing and using effective exposure assessment tools to prevent workplace illness and injury. EXA Program activities are guided by an internal steering committee with representation across NIOSH divisions. The EXA Program's Exposure Assessment Interest Group provides a forum for sharing needs, capabilities, and experience among NIOSH researchers. The breadth of external partnering with agencies and organizations includes the Occupational Safety and Health Administration, the U.S. Environmental Protection Agency, the U.S. Department of Energy, the Exposure Science 21 Federal Working Group, the American Industrial Hygiene Association, the Health Physics Society, the International Society for Exposure Science, and the Institute for Occupational Safety and Health of the German Social Accident Insurances.

NIOSH Guidelines Support Improved Development and Use of Real-Time Instruments

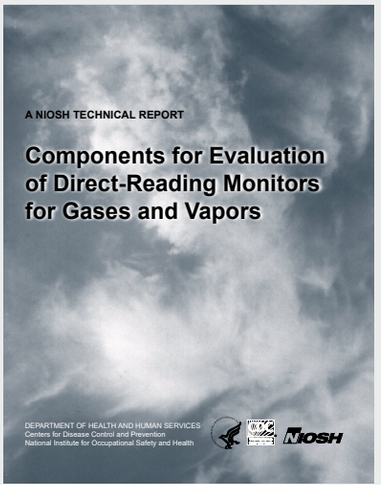
The use of new instruments and capabilities often raises questions about how to assure these devices measure what they say and are accurate enough to assure the safety of workers—especially in real-time situations. Advancements in sampling and analysis now enable practitioners to measure exposures without transporting a sample to a laboratory.

NIOSH recommended a wide variety of quality-check guidelines to keep pace with this progress. The guidelines help ensure proper use of real-time instruments and their reliability. As a result, NIOSH completed an innovative publication, "Components for Evaluation of Direct-Reading Monitors for Gases and Vapors" in 2012 [NIOSH 2012].

The NIOSH-designed publication is a starting point and a major step forward in assuring occupational safety and health in many workplaces.

Because of the NIOSH publication, instrument manufacturers, academics, instrument users, and government scientists are now better equipped to advance the future development and use of direct-reading instruments for assessing exposures. That means they have the real-time ability to measure the exposure of workers to potentially hazardous gases and vapors in the air directly. NIOSH continues to provide resources that routinely are used as a gold standard by industrial hygienists, and this allows these practitioners to do their job more quickly and efficiently, with confidence in accuracy and reliability.

Details: Components for Evaluation of Direct-Reading Monitors for Gases and Vapors



EXA Program contributions to NORA's second decade are evidenced by its advancing of the field and its consistent attraction of the greatest number of NORA proposals. The high number of views of the EXA Program-associated webpages also show the intense interest in the program. The EXA Program is behind only the Authoritative Recommendations and Personal Protective Equipment cross-sectors in terms of web-page views. The EXA Program has the second-most associated webpages of all the cross sectors on the NIOSH Internet.

During NORA's second decade, EXA strategic goals focused on providing critically needed guidance and on developing and improving exposure assessment methods and tools. Flagship activities included expanding the *NIOSH Manual of Analytical Methods (NMAM)*, establishing a program in direct-reading methods and monitors, and defining and initiating an occupational exposome effort.

Further activities and outcomes of the decade are described below.

- Publication of 20 new or updated NMAM methods, along with preparing a new edition for release in 2016. A recently completed survey of NMAM users confirmed the utility and value of this resource. The NMAM is the second-most-visited NIOSH website.
- Completion of the NIOSH Direct-Reading Methods and Monitors Initiative. A NIOSH-sponsored workshop and summary report engaged stakeholders to identify needs and gaps for direct-reading applications. Success of the initiative led to creating a new NIOSH Center for Direct Reading and Sensor Technologies (NCDRST).
- Knowledge of direct-reading opportunities for worker protection was improved through activities of the NIOSH Center for Direct Reading and Sensor Technologies. An article describing a comprehensive instrumentation lifecycle was authored by the NCDRST directors and published in *The Synergist* [Hoover and DeBord 2015]. This vision for "turning numbers into knowledge" was further shared in a widely viewed webinar on that topic.
- Commercialization of NIOSH-developed sensor technologies has been successful. During

the past 10 years, more than 36,000 devices based on exposure assessment technologies developed in NIOSH laboratories have been purchased commercially. These devices make exposure assessment information more accessible.

- Publication of NIOSH guidance on selecting direct-reading devices for gases and vapors [NIOSH 2012]. This guidance was accompanied by an addendum specific to emergency response. These publications are being used by the International Standards Organization (ISO) as it develops a standard for direct-reading devices.
- Publication of Genetics in the Workplace: Implications for Occupational Safety and Health [NIOSH 2010a]. This resource on an emerging challenge has been downloaded from the NIOSH website more than 1,000 times, and it has been used by the CDC Genomics Office as part of its basis for advancing public health.
- Creation of a NIOSH initiative on the occupational exposome. The occupational exposome was recognized as a director's special emphasis area for NIOSH intramural research. Key publications include an article describing biomarkers of response (omics technologies) and how they are used in setting occupational exposure limits, Another publication is an article serving as a primer on the exposome for the practice of epidemiology. Broad interest in this effort is evidenced by invitations from multiple organizations for presentations on the occupational exposome.

Global Collaborations

To improve global occupational safety and health, NIOSH established its Global Collaborations (GLC) Cross-sector Program to enhance global occupational safety and health through international collaborations. These strategic collaborations with public and private-sector-based partners provide NIOSH with opportunities to better conduct innovative research, deliver expert findings, and receive new information to protect the safety and health of workers worldwide. NIOSH conducted activities during NORA's second decade in close partnership with several national and international organizations, including WHO, International Labour Organization (ILO), Pan American Health Organization (PAHO), National Institutes of Health (NIH), ISO, IARC and the U.S. State Department. NIOSH has also been actively engaged with many countries, including Australia, Brazil, Canada, Chile, China, Columbia, Finland, Germany, India, Italy, Japan, Korea, Mexico, Netherlands, Peru, Singapore, South Africa, Sweden, Vietnam, United Kingdom, Venezuela, and Zambia.

The NIOSH Global Collaborations Program facilitates NIOSH Strategic Goal 3: "Enhance international workplace safety and health through global

NIOSH Partners with World Health Organization to Train Workers about Needle-Stick Injuries

NIOSH established a priority goal to globally reduce bloodborne pathogens among healthcare workers. These efforts led NIOSH and the World Health Organization to train about 20,000 workers from 34 countries. The NIOSH and WHO information is designed to educate government officials, frontline workers, and hospital leaders. The NIOSH and WHO "Protecting Healthcare Workers: Preventing Needlestick Injuries Toolkit" is used by staff members responsible for training. NIOSH will update the toolkit-training curriculum in 2016. Trainings occurred in Peru, Venezuela, Colombia, Brazil, Ecuador, Egypt, Morocco, Caribbean, Serbia, South Africa, Vietnam, and Tanzania.

The partnerships developed in several countries led to passing national legislation to better protect health workers in Venezuela, Peru, and Brazil. Of the more than 20,000 healthcare professionals trained globally—13,000 were in Latin America, 700 in Middle Eastern countries, and more 7,000 in African countries. The toolkit is now available in Spanish.

Details: Protecting Healthcare Workers: Preventing Needlestick Injuries Toolkit

collaborations," working with NIOSH staff. The program especially works with the NIOSH Office of the Director (OD), Respiratory Health Division (RHD), Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS), Education and Information Division (EID), Division of Applied Research and Technology (DART) , and Division of Safety Research (DSR). It also works with international agencies (WHO, PAHO, and ILO), international nongovernment organizations such as the International Commission on Occupational Health (ICOH), International Energy Agency (IEA), and International Occupational Hygiene Association (IOHA). It works with international entities that include the Worldwide Cleaning Industry Association (ISSA), National Social Security Administration of Argentina (ANSES), Social Service of Industry of Brazil (SESI), Sheffield Group, and the Partnership for European Research in Occupational Safety and Health (PEROSH). Finally, the program also works with country health and labor ministries around the world, along with 55 WHO Network Collaborating Centers in Occupational Health.

Further activities and outcomes associated with each of the GLC Program priority goals are described below.

Priority Goal: Enhance global occupational safety and health through international collaborations

- NIOSH chaired the network of 55 WHO Collaborating Centers and coordinated the project contributions of the centers in a common work plan.
- In 2015, NIOSH supported WHO by collecting 150 products and trainings from 46 WHO Network coordinating centers in 21 countries. This was included in the electronic repository, GeoLibrary.
- NIOSH helped WHO provide protection for health workers during the Ebola outbreak in Africa.

Priority Goal: Reduce global road traffic injuries of workers

- NIOSH organized the first International Conference on Road Safety at Work (2009).
- Work-related safety was included in U.N. road safety resolutions, based on NIOSH input.

Priority Goal: Reduce bloodborne pathogens among healthcare workers globally

- NIOSH and WHO produced the "Protecting Healthcare Workers: Preventing Needlestick Injuries Toolkit," and the training-of-trainers program for government officials, frontline workers, and hospital leaders.
- Instruction of 500 "super trainers" from 34 countries in the healthcare field led to training of about 20,000 health workers by the super trainers, to date.
- Work with international partners to assess incorporating the bloodborne pathogen curriculum modules into existing trainings and short courses for healthcare workers.
- Partnerships led the passing of national health worker legislation in Venezuela, Peru, and Brazil.

Priority Goal: Reduce silicosis through collaborations with the ILO/WHO Global Program

- NIOSH, WHO, PAHO, ILO, Chile, and countries in South America developed a program called the "Americas Silicosis Initiative." Trainings and assistance led to passage of the 2009 Chile National Plan to Eliminate Silicosis, development of a regional silica laboratory in Chile, development by Chile of simple guidance to control silica exposures in small businesses, and a program for respirator use in small businesses. The effort also led to trainings on control of silica exposure in various other countries.
- NIOSH helped ILO prepare the revised 2011 edition of the ILO Guidelines for International Classification of Radiographs of Pneumoconioses to extend applicability to digital radiographic images of the chest [ILO 2011]. Film trainings and digital training in radiographic reading and spirometry were conducted in many countries to develop national expertise, and materials were translated into various languages.

Health Hazard Evaluation

Many workers are exposed to potentially harmful conditions that could affect their health. The NIOSH Health Hazard Evaluation (HHE) Cross-sector

Coffee Roasting Health Hazard for Workers

During the past 15 years, some workers in plants that manufacture or use butter flavorings have been diagnosed with a serious and irreversible occupational lung disease, obliterative bronchiolitis. A common exposure across these industries associated with risk for this occupational illness has been exposure to flavorings that contain the chemicals diacetyl and 2,3-pentandione. NIOSH Health Hazard Evaluations contributed significantly to recognizing the hazard and recognizing interventions. In 2012, after physicians at a university medical center diagnosed obliterative bronchiolitis in five people who had worked at a coffee processing facility, NIOSH conducted a Health Hazard Evaluation at the facility to examine the potential risk for the work-related disease in current workers.

The findings of the Health Hazard Evaluation reinforced the need for evaluating work-related exposures in all industries in which workers are exposed to diacetyl or 2,3-pentanedione, and it resulted in NIOSH interim recommendations for measuring and reducing work-related exposures in coffee processing. By disseminating the information in a peer-reviewed journal and on the NIOSH webpage, NIOSH alerted physicians, employers, and workers to be aware of potential health risks, and the institute recommended practical, effective control measures.

Details: Flavorings-related Lung Disease

Photo by Thinkstock

Program offers unique federal government resources to employers and employees in all industry sectors of our nation's economy. Occupational safety and health professionals evaluate potential health hazards in the workplace and recommend action to eliminate those hazards and prevent adverse health outcomes. The program uses a practical, science-based approach to solve problems, and it provides its services at no cost to the employer or employees. The HHE Program was mandated by specific provisions of the Occupational Safety and Health Act of 1970 (Public Law 91-596) and the Federal Mine Safety and Health Act of 1977 (Public Law 91-173). The mission of the HHE Program is to respond to requests for worksite evaluations of health hazards, solve problems, communicate risk, and disseminate findings. As one of the NIOSH cross-sectors, the program identified three priorities that drive its activities: (1) to prevent illness through reduced exposure to workplace hazards, (2) to promote occupational safety and health research on emerging issues, and (3) to protect the safety and health of workers during public health emergencies.

The Health Hazard Evaluation (HHE) Program comprises NIOSH staff from two divisions: (1) the Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS), and (2) the Respiratory Health Division (RHD). Staff from other programs, primarily the Western States Division (WSD), Division of Applied Research and Technology (DART), and the Health Effects Laboratory Division (HELD), participate in HHE Program activities as needed. Extramural partners include OSHA, state and local health departments, and occupational medicine residency programs. The HHE Program considers employees and employers in the extramural community (and their representatives, such as trade associations and labor unions) as its stakeholders or customers.

During NORA's second decade, the HHE Program honed its strategic plan, with five strategic goals that have remained relevant throughout the decade. Primary emphasis was on increasing awareness of the HHE Program to ensure that (1) its services are available to meet the changing needs of the American workforce, and (2) the information learned from its investigations reaches all those who have a role in ensuring safe and healthy workplaces.

Outcomes of particular note include the following:

- Use of HHE Program findings to spur development and support a risk assessment for a NIOSH-recommended exposure limit for diacetyl.

- Adoption of HHE Program recommendations by third-party certification organizations to improve the health of electronic scrap industry employees.
- Survey results showing that 91% of responding stakeholders thought the HHE Program helped make things better at their workplace; for example, in the 2 years after implementing HHE recommendations at a poultry processing plant, the incidence of reported campylobacter infections decreased about 70%.
- HHE Program products have been distributed widely. For example, the American Industrial Hygiene Association (AIHA) reported that HHE Program items constituted 4 of the 10 most-popular stories in 2014.

Nanotechnology

The mission of the NIOSH Nanotechnology (NAN) Cross-sector Program is to provide national and international leadership in investigating the implications of nanoparticles and nanomaterials for work-related injury and illness, and to explore their potential applications in occupational safety and health. Nanotechnology is the manipulation of matter on a near-atomic scale to produce structures, materials, and devices that have new or unique properties. Nanoparticles are a subset of these new materials that have at least one dimension less than 100 nanometers. Nanotechnology has the ability to transform material science used in many industries, and it will have many applications to areas ranging from medicine to manufacturing.

With any new technology, the earliest and most-extensive exposures to hazards are most likely to occur in the workplace. Therefore, NIOSH engaged in a comprehensive effort to fill gaps about hazards and risks related to occupational exposure to engineered nanoparticles. This effort included determining whether nanoparticles and nanomaterials pose risks for work-related injury and illness; conducting research and making recommendations on effective methods to manage nanomaterials safely; promoting healthy workplaces through interventions, recommendations, and capacity building; and enhancing global workplace safety and health through national and international collaborations. By maintaining a dynamic approach involving strategic planning, research, partnerships, and information dissemination, the NAN Program, and the Nanotechnology Research Center (NTRC), are

Responsible Development of Nanotechnology Applications

Nanotechnology involves manipulating substances smaller than 100 nanometers, or less than one-thousandth the width of a human hair. Such substances can produce new materials, structures, and devices. Engineered nanomaterials are being incorporated into thousands of consumer and commercial products, from cosmetics and electronics to structural materials. The potential benefits of nanotechnology are immense, and these benefits should be fully realized by society. However, based on the toxicological behavior of some types of nanomaterials, concern exists about occupational exposure to nanomaterials, creating the need for these materials to be properly managed and controlled so that beneficial applications can be realized.

NIOSH developed a strategic program of collaborative research that resulted in a better understanding of the effects and potential occupational hazards of nanomaterials; methods to evaluate potential areas for worker exposures; guidance on hazard evaluation and risk assessment, including Recommended Exposure Limits; a framework for human health evaluation; guidance on engineering control strategies to minimize exposures; and general risk management guidance that ensures worker protection and promotes responsible development of nanotechnology. These products have responded to stakeholders' needs for strong scientific data and science-based recommendations in this emerging industry, have been widely cited and used by practitioners, and have been incorporated into actual work practices and international guidelines.

Details: Nanotechnology at NIOSH

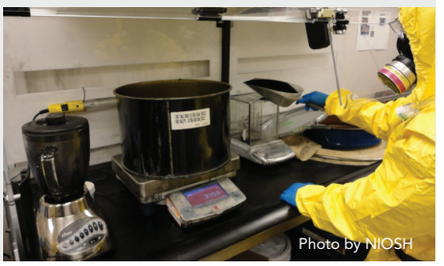


Photo by NIOSH

able to anticipate challenges and provide sound scientific recommendations for safely handling nanomaterials.

A key to the NTRC's ability to conduct relevant research and develop effective guidance has been the broad cross-institute intramural effort, and the success in creating productive voluntary partnerships and collaborations, including those with 65 companies in the private sector. Intramurally, the NTRC has participation from nearly every division, lab, or office in NIOSH. At the sector program level, NTRC activities and outputs support goals in Manufacturing, Construction, Healthcare, Exposure Assessment, and Respiratory Disease. To increase involvement with key extramural research centers, the NTRC entered into memorandums of understanding (MOUs) with SUNY Polytechnic Institute's Colleges of Nanoscale Science and Engineering (SUNY Poly CNSE), the Public-Private Partnership for Advanced Woody Biomaterials and Nanotechnology (P3Nano), and with the Center for High-Rate Nanomanufacturing (CHN). The NTRC has active collaborations with the American Industrial Hygiene Association (AIHA), the American Chemical Society (ACS), and the Center for Construction Research and Training (CPWR). NIOSH is a key contributor to the U.S. National Nanotechnology Initiative (NNI) and collaborates with 16 other government agencies through the working group on Nanotechnology Environmental and Health Implications (NEHI). Formal and informal agreements have been created with the National Institute for Standards and Technology (NIST), Consumer Product Safety Commission (CPSC), the Environmental Protection Agency (EPA), National Toxicology program (NTP), and the Occupational Safety and Health Administration (OSHA). Globally, NIOSH is working with the International Standards Organization (ISO), the Organization for Economic Cooperation and Development (OECD), World Health Organization (WHO), a United States/European Union (EU) harmonization workgroup, and several other EU occupational safety organizations.

In NORA's second decade, the NTRC has developed an effective program of research that has resulted in a better understanding of the hazards of nanomaterials; methods to evaluate potential areas for worker exposures; guidance on hazard evaluation and risk assessment, including Recommended Exposure Limits; a framework for human health evaluation; guidance on engineering control strategies to minimize exposures; and general risk management guidance that ensures worker protection and promotes responsible development of nanotechnology. Onsite evaluations of nanomanufacturing process investigations allowed NIOSH to measure worker exposures and develop recommendations for techniques to control and mitigate exposures. Key outcomes include actions from companies that have modified engineering controls, work practices, and in-house recommended exposure limits. NIOSH outputs have informed the manufacture of monitoring equipment to quantitatively measure air samples for nanoparticles. NIOSH and the SUNY Polytechnic Institute Colleges of Nanoscale Science and Engineering (CNSE) launched the Nano Health and Safety Consortium. Intermediate customers prepared reports, strategic research documents and briefings, or conducted demonstrations that leveraged or were informed by NIOSH nanotechnology-related research and outputs, which were then further disseminated through scientific and conferences related to occupational safety and health, along with meetings or virtual meetings (such as webinars). NTRC-authored publications have been cited more than 5,000 times in the peer reviewed scientific literature. These primary citations have resulted in over 82,000 secondary citations. A key to the success of the NAN Program has been the strong cross-Institute community that has been created.

Occupational Health Disparities

As the U.S. workforce becomes more diverse, disparities have become clear in the burden of work-related disease, disability, and death experienced by certain groups, such as low-income and foreign-born workers. Priority working populations have certain biological, social, or economic characteristics that place them at higher risk of developing work-related disease and injury. These populations include racial and ethnic minorities, immigrants, younger and older workers, workers with medical or genetic susceptibility, and workers with disabilities. Occupational health disparities arise in part from an over-representation in the most-hazardous industries, such as agriculture and construction. Other social, cultural, economic, and

Partnering With Mexican Ministries to Keep High-Risk Workers Safe

Certain population groups have a greater burden of work-related disease, disability, and death. For example, Latino immigrants are 50% more likely than all workers in the United States to suffer fatal work-related injuries.

A first step toward reducing risk is to provide meaningful information to Spanish-speaking immigrants to increase their awareness of workplace hazards and basic interventions available to them. They also need access to specialists who can help them navigate the labor and health systems, negotiate with managers, effectively act on their labor rights, and access services from organizations that advocate for and support immigrants and workers.

The NIOSH Occupational Health Disparities program has worked with Mexican ministries that sponsor programs in Mexican Consulates in the United States. They have collaborated to conduct research and prepare informational materials that effectively inform immigrant workers of their options if they face workplace hazards.

Three ministries in the Mexican government have improved their understanding of workplace issues in the United States and are now including occupational safety and health information as a main element of their outreach to Mexican citizens working in the United States. The infrastructure of the Mexican consular system also connects workers to the health, social, community, and legal services they may need to empower and advocate for themselves and reduce risk of work-related injury, illness, and death.

Details: A Partnership: NIOSH and Mexican Consulates Help Support the Health and Safety of Workers

Sample illustrations used in the Protéjase materials, highlighting the kinds of actions workers can take to protect themselves at work

political factors—including language, literacy, and marginal economic status—may compound their risks. These workers may also have less access to healthcare. Disparities are most apparent among populations with varying levels of socioeconomic status. A direct relationship exists between socioeconomic status and health, such that a person's overall health improves as that person's socioeconomic status improves. Health disparities between different racial and ethnic populations are likely to be related in part to differences in socioeconomic status, but they may also result from other interacting factors, such as discrimination. These factors are complex and still not completely understood.

The Occupational Health Disparities Cross-sector Program works to identify and eliminate health disparities by promoting effective research methods and disseminating tools and information to the occupational safety and health community. The program's priorities are the following:

- Improve surveillance of excess injury, illness, and death among priority working populations by enhancing the capacity of existing systems and improving survey design and administration to consider differences in language, literacy, and culture.
- Promote eliminating occupational health disparities by expanding outreach to stakeholders, such as community-based organizations, labor unions, and government agencies, and expanding efforts to develop practical intervention programs and policies that target priority working populations.
- Improve occupational safety and health research by increasing the capacity of researchers to address social and cultural dimensions of occupational health.
- Disseminate research tools and approaches that better consider factors such as language, literacy, and culture.

Program participants include an NIOSH-wide intramural committee, which has duties that include reviewing proposals submitted to the cross-sector for endorsement for NORA funding. The intramural committee was also instrumental in planning and participating in the First National Conference on Eliminating Health and Safety Disparities at Work conference.

Extramural partners included contributions from 20 U.S. universities; 3 foreign universities from Canada, Australia and Spain; other federal agencies, such as the National Institute of Environmental Health Sciences (NIEHS), OSHA, EPA, Chemical Safety Board, DHHS Environmental Justice Working Group; state and city health departments; and 6 labor and worker advocacy programs.

Researcher partners from U.S. universities and NIEHS collaborated on producing three modules (graduate, undergraduate, and worker) for teaching Occupational Health Disparities.

NIOSH has developed a collaboration with the Mexican Foreign Ministry to better understand the occupational safety and health needs of Mexican nationals working in the United States.

One of the main focuses for the cross-sector has been to have health disparities recognized as an occupational issue and included in larger efforts.

Following are the cross-sector's highlights from the past NORA decade:

- First National Conference on Eliminating Health and Safety Disparities at Work conference: five white papers produced on cross-cutting issues related to disparities.
- Inclusion of Occupational Safety and Health topics in the Department of Health and Human Services Environmental Justice Strategy.
- AJIM Special Issue, Achieving Health Equity in the Workplace.
- AJIM Special Issue, Occupational Health Disparities.
- Two Chapters in the 2013 CDC Health Disparities and Inequalities Report [CDC 2013a,b 2013].
- CDC Special Issue on Vulnerable Populations and Pandemic Influenza: two Papers on vulnerable workers included [Baron et al. 2009; Steege et al. 2009].
- Expanded Occupational Health Section or I/O coded in population-based surveys: National Health Interview Survey, Behavioral Risk Factor Surveillance Survey, Multi-Ethnic Study of Atherosclerosis, REasons for Geographic and Racial Differences in Stroke (REGARDS), Electronic Health Records.
- Collaboration with Mexican Foreign Ministry to include occupational health support for programs for its constituents in the United States.

Personal Protective Technology

Proper use of personal protective equipment and personal protective technology is the last line of defense in a hierarchy of controls used to minimize or eliminate exposure to hazards and reduce worker risk of potential injury, illness, and death. Personal protective technology consists of the specialized clothing or equipment worn by workers for protection, and it includes the technical methods, processes, techniques, tools, and materials that support their development and use. Personal protective technology includes respirators, gloves, protective eyewear, fall and hearing protection, and protective clothing. It also includes sensors to detect hazardous substances, guidance publications, performance standards, and test procedures. In 2001, Congress allocated funds to NIOSH to develop standards and technologies for protecting America's workers who rely on personal protective equipment, with emphasis on emergency responders.

NIOSH established its National Personal Protective Technology Laboratory (NPPTL) to provide national and world leadership for improved technologies, and to align NIOSH activities surrounding personal protective technology. This effort was emphasized and further developed in 2005, when NIOSH established the Personal Protective technology (PPT) Cross-sector Program. The PPT Program applies across all industry sectors and overlaps with NIOSH's Hearing Loss Program, Traumatic Injury Program, and Respiratory Disease Research Program, Emergency Preparedness and Response Program and Nanotechnology Program. This collaborative program fulfills its mission through respirator certification as mandated in federal regulations; focused research to improve workplace inhalation, dermal, and injury protections; development of interventions; participation in national and international standards, and policy development.

The relevance and sustainability of the PPT Program are achieved through the deliberate and continual involvement of its partners. Partners provide inputs, use the program's outputs, and join with the PPT Program to produce positive outcomes

Laboratory Evaluations and Interventions Encourage Use of Protection Equipment During Ebola Response

NIOSH led the national effort to support the proper use of Personal Protective Equipment (PPE) in the Ebola response by: (1) evaluating PPE ensembles used in West Africa to provide more guidance about avoiding heat stress, (2) reviewing existing test methods used to evaluate isolation gowns, (3) developing the scientific basis for improved test methods, and (4) developing communication products. NIOSH staff also served as consultants in an Ebola PPE response system to respond to questions from healthcare workers in the field (domestic and international) and employers. In total, NIOSH responded to more than 100 PPE inquiries during the peak of the response.

Most recently, NIOSH gave input to many U.S. government guidance documents and interim recommendations on a variety of Ebola PPE topics, including how to put PPE on and take it off, avoid heat stress, select protective clothing, and select and use powered air-purifying respirators. NIOSH began research studies to improve the scientific basis of the test methods used in the performance evaluation of PPE, including studies on fluid resistance, flammability, and liquid/viral barrier resistance. NIOSH human factors research established a baseline for the next generation of Ebola PPE coming from the U.S. Agency for International Development (USAID) and the White House Office of Science and Technology Policy (OSTP) initiative "Fighting Ebola: A Grand Challenge for Development."

Details: Fighting Ebola: A Grand Challenge for Development—How NIOSH is Helping Design Improved Personal Protective Equipment for Healthcare Workers

NIOSH sweating thermal manikin with the PPE ensemble commonly used by Médecins Sans Frontières (Doctors without Borders) for high exposure areas. This PPE ensemble includes a TyChem C coverall (a type of limited-use Chemical Protective Coverall), a custom-made Tyvek hood with integrated surgical mask, rubber apron, respirator, googles, rubber gloves, and rubber boots. Photo by NIOSH.

affecting worker safety and health. More than 100 partners are actively involved and are aligned with individual program projects. An estimated 20 million workers who use PPE have benefited from the Program's activities on respirators, clothing, and other PPE.

Intramural research partners included NIOSH DLOs with policy input from the NIOSH PPE Policy Group. The program also collaborates directly with NIOSH sector and cross-sector programs, with an emphasis in the Healthcare and Social Assistance, Mining, and Public Safety sectors

Extramural partners included other federal agencies, such as OSHA, MSHA, NIST, Food and Drug Administration (FDA), and the InterAgency Board. The PPT Program also collaborates with standards development organizations that include ASTM International, ANSI, ISO, NFPA and Association for the Advancement of Medical Instrumentation (AAMI). The PPT Program partners with the National Academy of Medicine Standing Committee on PPE for Workplace Safety and Health to discuss scientific and technical issues relevant to developing, certifying, deploying, and using PPE; standards; and related systems to improve workplace safety and health.

Further activities and outcomes during the decade are described below.

- Supported healthcare workers through collaborations with: (1) The American Association of Occupational Health Nurses (AAOHN), producing a 10-module Respiratory Protection Education and Resources Web Kit; (2) The Joint Commission, preparing a Respiratory Protection Monograph; (3) OSHA and the California Department of Public Health, preparing a Respiratory Protection Toolkit, leading to improved compliance with OSHA's

Respiratory Protection Standard and improved healthcare worker health and safety; and (4) respirator manufacturers, developing filtering facepiece respirators with attributes (such as comfort) desired by healthcare workers. The project BREATHE, Better Respirator Equipment using Advanced Technologies for Healthcare Employees, has produced 30 manuscripts.

- Maintained the searchable Certified Equipment List containing more than 9,000 certified respirators. In FY2014 alone, completed 560 certified respirator decisions (including 396 new approvals) and 311 respirator audits, improving the quality and inventory of respiratory protection devices for workers in multiple industries.
- Developed and implemented the new rule for NIOSH approval of closed-circuit escape respirators, providing improved respiratory protection for miners.
- Program outputs, including the Fire Fighter Fatality Investigation and Prevention Program and leadership on National Fire Protection Association (NFPA) committees, contributed to improved PPE standards developed by the NFPA. This yielded improved protection while meeting the Department of Homeland Security (DHS) mandate for certified product when purchased with DHS-FEMA grant funding.
- Formulated and led the more than 30-member public and private organization, PPT Conformity Assessment Working Group, to prepare a comprehensive set of reports that define the requirements for a national PPT Conformity Assessment framework for the nation (see PPT Conformity Assessment).
- Produced anthropometric research outputs for helping to develop better-fitting PPE, including respiratory and non-respiratory products. For example, various manufacturers reported in the past few years that the NIOSH digital headforms, manual anthropometric data, and 3D-scan data were used to design respirators, hard hats, ergonomic sports safety equipment, eye-protection products, headphones, models for artists, and adjustable headbands for neck-straightening exercise equipment.

Prevention through Design

One of the best ways to prevent occupational injuries, illnesses, and fatalities is to eliminate hazards and minimize risks early in the design or redesign process and incorporate methods of safe design into all phases of hazard and risk mitigation. The mission of the NIOSH Prevention through Design (PtD) Cross-sector Program is to prevent work-related injury, illness, and death through including prevention considerations in all designs that impact workers. The cross-sector program focuses on eliminating hazards and minimizing risks to workers throughout the lifecycle of work premises, tools, equipment, machinery, substances, and work processes—including their construction, manufacture, use, maintenance, and ultimate disposal or reuse. A growing number of business leaders recognize PtD as a cost-effective means to enhance occupational safety and health.

In 2007, building on the work of a critical mass of investigators and practitioners, NIOSH partnered with several organizations to launch a national Prevention through Design (PtD) initiative. Partners included the American Industrial Hygiene Association (AIHA); the American Society of Safety Engineers (ASSE); the Center for Construction Research and Training (CPWR); Kaiser Permanente; Liberty Mutual; the National Safety Council (NSC); the Occupational Safety and Health Administration (OSHA); ORCHSE Strategies, LLC (formerly Mercer, ORC Worldwide™); the Regenstrief Center for Healthcare Engineering; and the Association of Equipment Manufacturers. The initiative involved many partnerships with other government agencies, academia, industry, labor, and nongovernmental organizations to make an impact on research, education, policy, and practice related to preventing occupational hazards through design.

The ultimate goal of the Prevention through Design initiative is culture change, where eliminating worker hazards is considered at conceptual planning and design stages in the normal course of business operations. The work of NIOSH and its many partners have accelerated that culture change through advances in policy, education, research, practice, and small business.

Highlights of the PtD Program during the second decade include the following:

- Policy advances include more than 25 consensus standards revised to include PtD methods, highlighted by the milestone 2011 publication of the ANSI/ASSE z590.3 Prevention through Design standard that gives businesses specific methods they can use to build PtD into their operations [ANSI/ISEA 2011].
- The 2015 publishing of PtD pilot credits that can be followed to add points to "green building" certifications. These PtD credits were published by the U.S. Green Building Council for its globally-renowned Leadership in Energy and Environmental Design (LEED) certification program.
- The USGBC leadership reports that the use of these credits, and NIOSH-prepared LEED PtD webinars, is "amazing" among new pilot credits. These LEED PtD webinars are being used by design professionals around the world.
- Major PtD advances in education include engineering textbook revisions to incorporate PtD design methods and examples (with 10 through direct NIOSH PtD involvement, and at least 68 others independently revised).
- Development of 10 undergraduate PtD engineering educational modules were initiated by NIOSH PtD with the first 4 published in 2013.

NIOSH Prevention through Design Integrated Into LEED Green Building Certification

NIOSH leads the national Prevention through Design (PtD) initiative, which has a goal to promote "designing out" or minimizing workplace hazards and risks during the design of facilities, equipment, and processes. By designing safety into a workplace at the outset, businesses can better-protect workers from risks of job-related injury, illness, or death, and save the greater costs of retroactive correction, clean-up, and liability.

The Leadership in Energy and Environmental Design (LEED) Program, an environment-oriented building certification program operating under the auspices of the U.S. Green Building Council (USGBC), is a globally renowned rating system for sustainable buildings, and it is the most widely used. LEED is used to rate nearly two **million square feet daily. For developers, builders, and owners, this certification is commercially advantageous for attracting buyers, renters, and leasers who seek environmentally sustainable, cost-efficient business or residential space. It is also advantageous for property development in countries that require sustainable development or that provide financial incentives for "green" construction.** Prior to 2015, the LEED certification rating system addressed some health and well-being outcomes for building occupants, which includes managing indoor air quality. However, it did not focus on safety and health hazards affecting construction workers, building operations staff, and maintenance staff.

NIOSH initiated a partnership with USGBC to develop and publish a new pilot credit focused on PtD practices. It addresses health and safety issues related to two important building lifecycle phases—operations and maintenance, and design and construction. Addressing the credit helps to attain the "green building" certification, while promoting safer, healthier work environments for those who construct, maintain, and occupy buildings.

USGBC hails its partnership with NIOSH for expanding the scope of the LEED rating system to include safety and health issues for those who construct and maintain facilities. U.S. Green Building Council leadership reports that 25 building projects internationally have registered for the LEED PtD pilot credit, including projects in the United States, Ireland, and Qatar. A completed project in Vienna, Austria, was awarded a prestigious LEED Gold certification. By participating in the educational webinars developed by NIOSH for the PtD pilot credit, 647 design professionals around the world have earned continuing education credits.

Details: New LEED Pilot Credit: Prevention through Design

Photo by Thinkstock

- Research and practice advances in PtD resulted as NIOSH and partners have published case studies demonstrating positive return on investment business cases for PtD methods and designs.
- On-the-ground assembly and modular and prefabricated components that are hoisted into place are eliminating many fall hazards while adding productivity, reducing costs, and reducing worker injuries.
- Businesses are including safe access for future operating and maintenance work in their designs for dangerous locations, such as access to tall ceilings and lighting, rooftop protection using parapets, and guarding of skylights.
- PtD case studies have contributed to the greatly increased availability and use of mechanical patient-lifting devices in the healthcare industry, which greatly reduces injuries and worker compensation costs.
- Small businesses are benefiting from PtD work done across NIOSH, leading to quieter power tools, safer nail guns, increased awareness of safe ladder use, and more.

Small Business Assistance and Outreach

The mission of the Small Business Assistance and Outreach (SBA) Cross-sector Program is to reduce occupational diseases, injuries, and fatalities that occur in small business establishments. This is accomplished through a comprehensive program involving research, prevention efforts, and public health activities. The SBA Cross-sector Program spans all workplace sectors. The program conducts high-quality research; develops and disseminates practical solutions to complex workplace safety and health problems; fosters partnerships with labor, industry, government, and other stakeholders; and promotes the transfer of research to practice.

Internal partners include NIOSH divisions, labs, and offices and NIOSH sector and cross-sector programs. External partnerships developed over the decade have included trade associations, professional organizations, national business organizations, local chambers of commerce, state OSHA and workers' compensation providers, academic institutions, local health departments, business health service providers, and federal OSHA.

In the late 1990s and early 2000s, the NIOSH efforts in improving occupational safety and health

NIOSH Small Business Resource Guide Attracts Users

In 2012, firms with fewer than 20 workers made up about 90% of companies and employed almost 18% of U.S. workers. Smaller businesses tend to have higher workplace illness, injury, and fatality rates than larger ones.

NIOSH is interested in demonstrating economically viable, practical solutions for common safety issues in small businesses, and it seeks to provide clear and effective tools for small businesses to improve health and safety in their workplaces.

The "NIOSH Small Business Resource Guide" is a collection of links to information identified as being valuable for small-business owners. The information is provided by organizations across the occupational safety and health community and includes topics on insurance and compliance, emergency preparedness, guides and handbooks, and safety plans. Many other influential organizations, including the Small Business Administration and local chambers of commerce, have linked to the NIOSH guide from their websites. The NIOSH Small Business Resource Guide is viewed 400 to 500 times a month. Reflecting user needs, items in the guide that received little interest in an earlier version were removed, while terms of high interest were given more priority. Users tend to find the guide using popular search engines, with common keywords including "checklist," "safety plan," or "safety tips."

Details: Small Business

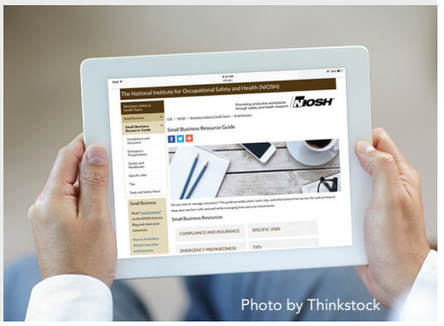


Photo by Thinkstock

in small business included the NIOSH publications, "Identifying High-Risk Small Business Industries" [NIOSH 1999b] and the "Safety and Health Resource Guide for Small Businesses" [NIOSH 2000], as well as a project that delivered occupational safety and health assistance materials to small businesses through partnerships with the National Federation of Independent Businesses and the Ohio Bureau of Workers' Compensation. The foundational work of these projects led to developing the Small Business Assistance Office (SBAO) Program in 2006. Initial program activity included two town hall meetings in 2006, and a stakeholder meeting in 2008 included several national experts in small business occupational safety and health. This work resulted in the first national small business occupational safety and health research agenda, which has subsequently been revised to reflect the evolution of the SBAO Program.

Surveillance

Occupational safety and health surveillance is the ongoing systematic collection, analysis, interpretation, and dissemination of information used to describe workplace injury, illness, hazard, and exposure. Occupational safety and health surveillance information helps determine where work-related injuries and illnesses occur, how frequently they happen, and where scarce resources can most effectively be applied to eliminate or reduce the injury and illness burden to workers. Whether applied to known exposures or new exposures from newly developed products, a well-designed surveillance program allows researchers to recognize potential health hazards in industry and develop interventions that will eliminate or reduce the health impact upon workers. Identifying and tracking occupational injuries, illnesses, and hazards for the nation is fundamental to the NIOSH mission. To this end, the Surveillance (SUR) Program strives to provide quantitative estimates of injuries, fatalities, and occupational diseases; detect trends, outbreaks, or epidemics of workplace injuries and diseases; monitor changes in known hazards; identify emerging hazards in the workplace; facilitate epidemiologic and laboratory research; generate new hypotheses for workplace safety and health; evaluate control and prevention measures aimed at improving safety and health; develop new technologies to improve surveillance data collection, management, and analysis; and provide results to the widest-possible audience. NIOSH actively partners with federal and state agencies and private-sector programs to conduct studies and communicate findings of occupational health surveillance research.

The Surveillance Cross-sector Program includes the surveillance work of all NIOSH divisions, labs, and offices. NIOSH scientists work with federal partners, state health and labor departments, academia, and professional associations (such as CSTE, the Council of State and Territorial Epidemiologists). The connection between surveillance and end-impact (such as reducing work-related injuries and illnesses) is often indirect and can span many years; this fact is reflected in the types of impact most common from research in the Surveillance Program.

Further activities and outcomes during the decade by each strategic goal (SG) are described below.

SG1: "Enhance national surveillance systems to prevent occupational illnesses, injuries, and hazards."

- Demonstrated the utility and feasibility of including industry and occupation in the Behavioral Risk Factor Surveillance System (BRFSS) core, with 25 states participating. States are analyzing the data and reporting the results in peer-reviewed journals and other publications (N=9).
- Demonstrated utility of the Behavioral Risk Factor Surveillance System (BRFSS) Asthma Call-back Survey (ACBS) with up to 35 states participating. NIOSH and states published the results in peer-reviewed journals and other publications (N=16).
- Conducted occupational health supplements to the National Health Interview Survey in 2010 and 2015, publishing 16 peer-reviewed journal articles, 1 MMWR article, and providing sector-specific prevalence of health outcomes and exposures. Data from the 2010 Supplement were used to establish a baseline for the 2020 Healthy People respiratory disease objective, RD-7.8.
- Collected occupational injury data through the National Electronic Injury Surveillance System—

Occupational Supplement (NEISS-Work), which were used to update child labor laws.

- Launched a query system called Work-RISQS, making data from NEISS-Work publicly available. Work-RISQS allows users to produce national estimates of emergency-department-treated occupational injuries by demographics, nature of injury, and injury incident characteristics.
- Produced a series of articles in peer-reviewed journals on tobacco use among workers.
- Provided quality control for 22,000 spirograms for the NHANES 2007–2012 surveys.

SG2: "Enhance state-based surveillance systems and use of data at both the state and national levels to prevent occupational illnesses, injuries, and hazards."

- Launched the state-based Occupational Health Clearinghouse to enable state-generated occupational health products to be shared widely through the Internet. It includes more than 4,200 documents from 26 states.
- Expanded the number of states with occupational health and exposure surveillance programs from 15 to 26 and supported state-based surveillance of acute pesticide-related illness and injury, occupational traumatic fatalities, elevated blood lead levels in adults, work-related asthma, and silicosis. Example of impact—EPA updated its Agricultural Worker Protection Standard using NIOSH SENSOR-Pesticides data and publications. In collaboration with CSTE, reduced the recommended adult blood lead level to 5 µg/dL from 25 µg/dL.
- Raised awareness of emerging hazards by working with states, such as the New Jersey and Texas state occupational health partners. This brought to light hazards of fabricating engineered stone countertops, through a NIOSH Science Blog article, and an OSHA-NIOSH Hazard Alert. The first case of silicosis from engineered stone in the United States was documented in MMWR "Notes from the Field." Other documented hazards include occupational methylene chloride deaths associated with bathtub refinishing through state Fatality Assessment and Control Evaluation (FACE) reports and an OSHA-NIOSH Hazard Alert, and fatalities to temporary workers through state FACE reports and an OSHA-NIOSH Recommended Practices document.
- Made recommendations to the Federal Aviation Administration (FAA) to prevent air collisions in Alaska by changing radio frequencies used by pilots and airports. Recommendations were accepted by the FAA, and changes were in effect on May 29, 2014.

SG3: "Enhance sector-specific surveillance systems to prevent occupational illnesses, injuries, and hazards."

- Conducted and published the U.S. Survey of Long-haul Truck Drivers, the first population-based survey of its kind; demonstrated the significant relationship between obesity, smoking, and work as long-haul truck driver; increased awareness of truck-driver safety and lack of seat belt use through March 2015 publications in MMWR and CDC Vital Signs.
- Evaluated best practices in more than 22 healthcare disciplines, using a web-based survey for prevention of exposure to anesthetic gases, surgical smoke, antineoplastic drug administration and formulation, and other hazards. Demonstrated that despite existing guidelines being improved, and more consistent worker training and management vigilance is needed to ensure guidance is followed.
- Issued publications providing rates for health outcomes and selected exposures for each of eight NORA sectors from analysis of the National Health Interview Survey 1997–2012.
- Published a journal article that documented increasing prevalence of black lung disease among current coal miners.
- Evaluated current knowledge of metal and nonmetal miner health status and summarized these findings in a journal article published February 2015.
- Developed new Mining Industry Surveillance System surveys, conducted on a rotating basis, in mining sectors aligned with national mining associations.

- Conducted surveillance of personal protective equipment use among pesticide handlers, healthcare workers, and farm operators.
- Conducted a fatality investigation of nine worker deaths due to overexposure to hydrocarbon gases and vapors while the workers manually gauged tanks. Produced a NIOSH Hazard Alert, which helped the American Petroleum Institute to develop a new standard. This may have played a role in reducing attributed fatalities in 2015 to zero.
- Demonstrated importance of surveillance at the fleet level to better understand safety issues in fishing fleets. The U.S. Coast Guard used findings from surveillance data to develop fleet safety programs across the United States.
- Developed a new passive-guarding system for deck winches as a result of surveillance and analytic epidemiologic studies of nonfatal and fatal injuries at a Gulf of Mexico shrimp fishery.
- Investigated fire-fighter traumatic and medically related line-of-duty deaths, through the efforts of the Fire Fighter Fatality Investigation and Prevention Program. Investigators traveled to the site of the fatalities to recommend methods to reduce similar fatalities within the fire service.
- Conducted surveillance of farm-related injuries to youth on farms, farm operators, and farm workers through surveys conducted for NIOSH by the U.S. Department of Agriculture or the U.S. Department of Labor.

SG4: This strategic goal was retired in FY15 because of overlap with other SGs.

SG5: "Develop new methods for surveillance of occupational illnesses, injuries, and hazards."

- Developed and launched the NIOSH Industry and Occupation Computerized Coding System, a web-based industry and occupation coding system. Coded 16 million records since 2012, significantly more than using only coders. This saved NIOSH $1.25 million in coding costs.
- Formulated plans with CDC to include industry and occupation in all CDC surveillance systems.
- Worked through the Council of State and Territorial Epidemiologists (CSTE) to successfully reduce the recommended maximum blood lead level from 10 µg/dL in adults to 5 µg/dL. Identified new sources of adult lead exposure in U.S. workplaces.
- Established Occupational Health Indicators, working through CSTE, which made silicosis,

Acute Illnesses Associated With Pesticide Exposure at Schools

Pesticide exposure can result in acute illnesses if these chemicals are applied improperly, exposures are not effectively controlled, and exposures exceed safe limits. Schools may use pesticides on-site, or they may be in the path of pesticides drifting from neighboring farm fields. The magnitude of these exposures, and the associated risk for the health of employees and students, were not well-measured. As a result, the public and private sectors often lacked scientifically sound data on which to base decisions for employee and student safety. NIOSH assessed the risk factors for pesticide-related illnesses at schools to help fill this knowledge gap, help prevent pesticide-related illnesses at schools, improve practices to reduce pesticide drift from nearby farms, and recommend pesticide spray buffer zones around schools.

Because of the NIOSH work, the U.S. Environmental Protection Agency (EPA), advocacy groups, universities, state regulators, the pest-control industry, and others, helped create laws or strong voluntary programs in several states. Five states supplemented the federal law to create more stringent state pesticide laws to protect children from pesticides at schools. The laws require schools to control pests using methods with the least-possible health risks.

Details: Acute Illnesses Associated With Pesticide Exposure at Schools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adult blood lead, and acute pesticide poisoning nationally notifiable conditions.

- Established a NIOSH workgroup to address collection of work, including industry and occupation, in electronic health records (EHRs), to further occupational safety and health surveillance and research.
- Raised recognition of work information as critical for including in EHRs by commissioning the International Organization for Migration (IOM) Letter Report, "Incorporating Occupational Information in Electronic Health Records" [Wegman et al. 2011].
- Expanded surveillance of health and injury outcomes among healthcare workers employed in healthcare facilities through the web-based Occupational Health and Safety Network (OHSN). Traumatic injury from patient-handling is found to be highest in nurses and nursing assistants.
- Expanded the use of follow-back studies through the National Electronic Injury Surveillance System—Occupational Supplement (NEISS-Work) to conduct studies on occupational assaults, needlestick injuries, injuries to Emergency Medical Service workers, and assess underreporting of occupational injuries
- Worked with the Bureau of Labor Statistics (BLS) and the National Highway Traffic Safety Administration (NHTSA) to match occupational motor vehicle fatality data from the BLS Census of Fatal Occupational Injuries (CFOI) with the NHTSA Fatality Analysis Reporting System (FARS). The matched data set provides a unique view of occupational motor-vehicle deaths by combining the detailed demographic data from the CFOI with the detailed crash data from the FARS.

The connection between surveillance and end-impact (such as reducing work-related injuries and illnesses) is often indirect and can span many years; this fact is reflected in the types of impact most common from research in the Surveillance Program.

Total Worker Health®

The health risks and challenges facing today's workers and employers are significantly different than they were when the Occupational Safety and Health Act of 1970 was signed into law. Today's workers face not only the traditional risks of chemical, physical, and biological hazards, but also increased risks related to the changing nature of work, shifting workforce demographics and diversity, evolving employment patterns, and the changing workplace environment. In 2003, NIOSH started the Steps to a Healthier U.S. Workforce Initiative to explore the benefits of integrating the protection of workers from work-related safety and health hazards with efforts to prevent illness and injury, in order to advance the comprehensive safety, health, and well-being of workers. One of the important outcomes of this initiative was the 2004 Steps to a Healthier U.S. Workforce Symposium (Steps Symposium), which received overwhelming support from the stakeholder community [Schill and Chosewood, 2013]. Building on this enthusiastic support, the "Steps" initiative developed into the WorkLife Initiative. In 2011, NIOSH renamed its efforts from WorkLife to the Total Worker Health® Program (TWH).

Building on four decades of scientific knowledge to prevent worker injury and illness, the TWH Cross-sector Program supports ground-breaking research that addresses the health implications of today's changing workplace and responds to demands for information and practical solutions to the health, safety, and well-being challenges that workers face. The concept of Total Worker Health® is defined as policies, programs, and practices that integrate work-related safety and health hazard protections with efforts to promote methods to prevent injury and illness, which advances worker well-being. This approach prioritizes a hazard-free work environment for all workers and comprehensively integrates workplace systems relevant to controlling hazards and exposures, organization of work, compensation and benefits, work-life integration/management, and organizational change management. Over the past 10 years, NIOSH and its extramural research Centers of Excellence to Promote a Healthier Workforce have advanced the growing body of evidence that shows combining occupational safety and health-protection program activities with workplace programs to prevent injury and illness is more effective at safeguarding worker safety, health, and well-being. Combining these

efforts produces better results than either of these programmatic activities alone.

Over the past decade, the NIOSH Total Worker Health® (TWH) Cross-sector Program has strengthened long-standing collaborations and developed novel, innovative partnerships to safeguard workers and expand their health and well-being. Partners include NIOSH-funded extramural academic Centers of Excellence, and hundreds of occupational safety and health practitioners and researchers, workplace health and well-being professionals, labor partners, employers, and policymakers. In 2014, the TWH Program launched the NIOSH TWH Affiliate Program to extend the impact and elevate the visibility of worker safety and health priorities. The Affiliates Program has 24 members representing universities, departments of public health, healthcare systems, labor organizations, federal agencies, and councils.

Further activities and outcomes during the second decade are described below.

- During NORA's second decade, NIOSH launched and registered the trademark for the Total Worker Health® Program, catapulted communication and research-to-practice efforts, and brought new audiences to occupational safety and health. Since 2011, more than 15,000 workplace safety and health professionals participated in TWH trainings through in-person workshops, meetings, webinars, consultations, and other live forums. The e-newsletter reaches more than 62,000 people quarterly.
- NIOSH funded four Centers of Excellence for Total Worker Health® during the second decade. The centers have published many peer-reviewed research articles, conducted critical workplace health surveys, and developed toolkits, training programs, and educational materials for workers and organizations across the nation.
- To advance intramural capacity for TWH, NIOSH formed an internal steering committee of more than 60 NIOSH scientists to champion research integration with the Centers of Excellence, developed an intramural Seminar Series, developed TWH project-coding guidance for NIOSH project officers, and obtained special emphasis funding to advance collaborative research.

Dartmouth-Hitchcock Partners with NIOSH to Implement *Total Worker Health®*

The NIOSH Total Worker Health® (TWH) program promotes a common-sense approach to safeguarding workers—one that recognizes that protecting workers is enhanced by continuously nurturing a culture of safety, health, and well-being in the workplace. When work is safer and workplaces are healthier, workers and employers both benefit.

NIOSH offers a TWH Affiliate program in which academic, nonprofit, labor, and government organizations collaborate to promote TWH research and practice, pilot-test interventions, and launch innovative programs within their own organizations.

The Dartmouth-Hitchcock Medical Center became an inaugural member of the TWH Affiliate program in 2014. Dartmouth-Hitchcock promotes and implements Total Worker Health® through its Live Well/Work Well program. Live Well/Work Well provides holistic health and safety services for Dartmouth-Hitchcock employees by linking safety, occupational health, mental-health services, primary care, and prevention efforts. One innovative component of the Live Well/Work Well program identifies high-risk work units in the medical center and offers preventive interventions, including purchasing new safety technology or equipment, addressing the health implications of work schedules, or retraining managers and staff to work together more effectively to identify and address risk factors. The TWH-enhanced program benefits the health and safety of the medical center's more than 8,000 employees and provides a model for innovative programs by other healthcare industry leaders.

Details: TWH® in Action!

- TWH published the NIOSH Compendium of Seminal Papers on Total Worker Health®, a bibliography of high-profile TWH literature and reports and practice-based guidance, reaching a combined quarterly average of 10,000 unique website visitors.
- In 2014, the TWH Program commissioned an Institute of Medicine workshop and report that identified best practices for integrating worker safety with other workplace health programs; that same year, the TWH Program held the first International Symposium on Total Worker Health®, with 350 collaborating experts and practitioners.
- In 2015, TWH Program launched the NIOSH Center for Productive Aging and Work to champion, consolidate, and provide expertise and guidance on productive aging across the working lifespan.
- Partnering with NIH, the TWH Program convened the Pathways to Prevention workshop to evaluate the current state of knowledge on integrated approaches to worker safety, health, and well-being and plot the direction for future research. Collaborating with stakeholders, the TWH Program developed and published in April 2016 a "National TWH Agenda" publication to highlight priority research, practice, policy, and capacity-building goals for the decade ahead.

REFERENCES

ANA [2013]. Safe patient handling and mobility: interprofessional national standards. Silver Spring, MD: American Nurses Association.

ANSI/ISEA [2011]. ANSI Z590.3-2011 Prevention through design guidelines for addressing occupational hazards and risks in design and redesign processes. Washington, DC: American National Standards Institute.

ASTM [2014]. ASTM D7558-09(2014) Standard test method for colorimetric/spectrophotometric procedure to quantify extractable chemical dialkyldithiocarbamate, thiuram, and mercaptobenzothiazole accelerators in natural rubber latex and nitrile gloves. West Conshohocken, PA: ASTM International.

Baron SL, McPhaul K, Phillips S, Gershon R, Lipscomb J [2009]. Protecting home health care workers: a challenge to pandemic influenza preparedness planning. Am J Public Health, *99*(Suppl 2), S301–S307, http://dx.doi.org/10.2105/AJPH.2008.157339.

CDC [2013a]. Fatal work-related injuries—United States, 2005–2009. MMWR Supplements, *62*(3): 41–45.

CDC [2013b]. Nonfatal work-related injuries and illnesses—United States, 2010. MMWR Supplements, *62*(3):35–40.

Child labor regulations, orders and statements of interpretation. 29 CFR Parts 570 and 579 (2010).

DOD [2015]. MIL-STD-1474E Department of defense design criteria standard noise limits. Washington, DC: U.S. Department of Defense, https://www.arl.army.mil/www/pages/343/MIL-STD-1474E-Final-15Apr2015.pdf.

ECOLOGO® [2011]. UL 2759 Standard for sustainability for hard surface cleaners. Northbrook, IL: ECOLOGO®.

Gillen M, Goldenhar LM, Hecker S, Schneider S [2014]. Safety culture and climate in construction: bridging the gap between research and practice. Silver Spring, MD: The Center for Construction Research and Training.

Green Seal [2015]. GS-37 Cleaning products for industrial and institutional use. Washington, DC: Green Seal Standard for Industrial and Institutional Cleaners.

Hammer L, Ganster, D [2014]. Presentation on intervening for work stress: work-life stress and total worker health approaches sponsored by office of Total Worker Health® and Work Organization and Stress-Related Disorders Research Program, August 19.

Haupt A [2013]. U.S. Twitter chat on sleep health. U.S. News and World Report, August 28, http://health.usnews.com/health-news/health-wellness/articles/2013/08/28/us-news-twitter-chat-on-sleep-health.

Hoover MD, DeBord DG [2015]. Turning numbers into knowledge: sensors for safety, health, well-being, and productivity. The Synergist, March, http://synergist.aiha.org/the-synergist-march-2015.

ILO [2011]. Guidelines for the use of the ILO international classification of radiographs of pneumoconioses, revised edition. Geneva, Switzerland: International Labour Organization.

ISO [2003]. ISO 11228-1:2003(en) Ergonomics—manual handling—part 1. Geneva, Switzerland: International Organization for Standardization.

ISO [2013]. ISO 1999:2013 (en) Acoustics—estimation of noise-induced hearing loss. Geneva, Switzerland: International Organization for Standardization.

Lowering miners' exposure to respirable coal mine dust, including continuous personal dust monitors. 30 CFR 70, 71, 72, 75, and 90 (2014).

Lu ML, Waters T, Krieg E, Werren D [2013]. Efficacy of the Revised NIOSH Lifting Equation to predict risk of low back pain associated with manual lifting: a one-year prospective study. Hum Factors *56*(1): 73–85.

MSHA [2010]. 30 CFR 75.403 Maintenance of incombustible content of rock dust. Washington, DC: Mine Safety and Health Administration, https://www.gpo.gov/fdsys/pkg/CFR-2014-title30-vol1/pdf/CFR-2014-title30-vol1.pdf.

NIOSH [1999a]. Stress … at work. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 1999-101.

NIOSH [1999b]. NIOSH special hazard review: identifying high-risk small business industries. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 1999-107, http://www.cdc.gov/niosh/docs/99-107/pdfs/99-107.pdf.

NIOSH [2000]. Safety and health resource guide for small business. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2000-148, http://webapp1.dlib.indiana.edu/virtual_disk_library/index.cgi/5678550/FID2757/niosh_small_busines_guide/00-148.pdf.

NIOSH [2004]. Preventing occupational exposure to antineoplastic and other hazardous drugs in health care settings. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2004-165.

NIOSH [2010a]. Genetics in the workplace: implications for Occupational Safety and Health. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2010-101.

NIOSH [2010b]. Delivering on the nation's investment in worker safety and health. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2010-122.

NIOSH [2011a]. Get valid spirometry results every time. Poster. Morgantown, WV: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2011-135, https://www.cdc.gov/niosh/docs/2011-135/pdfs/2011-135.pdf.

NIOSH [2011b]. Current intelligence bulletin 61: a strategy for assigning new NIOSH Skin Notations. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2011-154.

NIOSH [2012]. A NIOSH technical report: components for evaluation of direct-reading monitors for gases and vapors. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2012-162.

NIOSH [2014]. Recommended practices: protecting temporary workers. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2014-139.

NIOSH [2015a]. Ergonomic solutions for retailers. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2015-100.

NIOSH [2015b]. Current intelligence bulletin 67: promoting health and preventing disease and injury through workplace tobacco policies. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2015-113.

NIOSH [2015c]. NIOSH training for nurses on shift work and long work hours. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2015-115.

NIOSH [2015d]. Reproductive health and the workplace. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, https://www.cdc.gov/niosh/topics/repro/.

NTP (National Toxicology Program) [2014]. *Report on carcinogens, 13th edition.* Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service, http://ntp.niehs.nih.gov/pubhealth/roc/roc13/.

OSHA [2016]. Occupational Exposure to Crystalline Silica. Final rule. Fed Regist *81*(58):16285 (to be codified at 29 CFR 1910, 1915, and 1926).

Schill AL, Chosewood LC [2013]. The NIOSH Total Worker Health® program: an overview. J Occup Environ Med *55*(Suppl 12):S8–S11, http://dx.doi.org/10.1097/JOM.0000000000000037.

Steege AL, Baron SL, Davis S, Torres-Kilgore J, Sweeney MH [2009]. Pandemic influenza and farmworkers: the effects of employment, social, and economic factors. American Journal of Public Health, 99(Suppl 2), S308–S315.

Wegman DH, Liverman CT, Schultz AM, Strawbridge LM, eds. [2011]. Incorporating occupational information in electronic health records: letter report. Washington DC: National Academies Press.

LIST OF WEB LINKS

For printed versions of this supplement, web links are listed alphabetically, along with their corresponding web addresses.

2013 CDC Health Disparities and Inequalities Report, http://www.cdc.gov/mmwr/pdf/other/su6203.pdf

A Partnership: NIOSH and Mexican Consulates Help Support the Health and Safety of Workers, http://blogs.cdc.gov/niosh-science-blog/2015/09/23/protejase4/

Achieving Health Equity in the Workplace, http://onlinelibrary.wiley.com/doi/10.1002/ajim.v57.5/issuetoc

Acute Illnesses Associated With Pesticide Exposure at Schools, http://www.cdc.gov/niosh/nioshtic-2/20027916.html

AJPH CDC Special Issue on Vulnerable Populations and Pandemic Influenza, http://ajph.aphapublications.org/toc/ajph/99/S2

Best Practice Engineering Control Guidelines to Control Worker Exposure to Respirable Crystalline Silica During Asphalt Pavement Milling, http://www.cdc.gov/niosh/docs/2015-105/

Best Practice Engineering Control Guidelines to Control Worker Exposure to Respirable Crystalline Silica During Asphalt Pavement Milling, http://www.cdc.gov/niosh/docs/2015-105

Best Practices: Engineering Controls, Work Practices, and Exposure Monitoring for Occupational Exposures to Diacetyl and 2,3-Pentanedione, http://www.cdc.gov/niosh/docs/2015-197/default.html

Campaign to Prevent Falls in Construction, http://www.cdc.gov/niosh/construction/stopfalls.html

CDC Health Disparities and Inequalities Report, http://www.cdc.gov/mmwr/pdf/other/su6203.pdf

Census of Fatal Occupational Injuries, http://www.bls.gov/iif/

Components for Evaluation of Direct-Reading Monitors for Gases and Vapors, http://www.cdc.gov/niosh/docs/2012-162

Control Worker Exposure to Respirable Crystalline Silica During Asphalt Pavement Milling, http://www.cdc.gov/niosh/docs/2015-105/pdfs/2015-105.pdf

Criteria for a Recommended Standard: Occupational Exposure to Hexavalent Chromium, http://www.cdc.gov/niosh/docs/2013-128/

Criteria for a Recommended Standard: Occupational Exposure to Metalworking Fluids, http://www.cdc.gov/niosh/docs/98-102/default.html

Criteria for a Recommended Standard: Occupational Exposure to Refractory Ceramic Fibers, http://www.cdc.gov/niosh/docs/2006-123/

Current Intelligence Bulletin 61: A Strategy for Assigning New NIOSH Skin Notations, http://www.cdc.gov/niosh/docs/2009-147/

Current Intelligence Bulletin 62: Asbestos Fibers and Other Elongate Mineral Particles: State of the Science and Roadmap for Research, http://www.cdc.gov/niosh/docs/2011-159/

Current Intelligence Bulletin 63: Occupational Exposure to Titanium Dioxide, http://www.cdc.gov/niosh/docs/2011-160/

Current Intelligence Bulletin 65: Occupational Exposure to Carbon Nanotubes and Nanofibers, http://www.cdc.gov/niosh/docs/2013-145/

Current Intelligence Bulletin 66: Derivation of Immediately Dangerous to Life or Health (IDLH) Values, http://www.cdc.gov/niosh/docs/2014-100/

Current Population Survey, http://www.bls.gov/cps/

ECN Program's website, http://www.cdc.gov/niosh/programs/econ/

Emergency Responder Health Monitoring and Surveillance (ERHMS), http://www.cdc.gov/niosh/topics/erhms

Emergency Responder Long Work Hours Training, http://www.cdc.gov/niosh/updates/upd-12-03-2014.html

Ergonomic Solutions for Retailers, http://www.cdc.gov/niosh/docs/2015-100

Evaluation of the Impact of the Revised National Institute for Occupational Safety and Health Lifting Equation, http://dx.doi.org/10.1177/0018720815623894

Falls in the Workplace, http://www.cdc.gov/niosh/topics/falls

Field Guide for Controlling Silica Dust Exposure on Asphalt Pavement Milling Machines, http://www.silica-safe.org/training-and-other-resources/manuals-and-guides/asset/Field-Guide-for-Controlling-Silica-Dust-Exposure-on-Asphalt-Pavement-Milling-Machines.pdf

Fighting Ebola: A Grand Challenge for Development—How NIOSH is Helping Design Improved Personal Protective Equipment for Healthcare Workers, http://blogs.cdc.gov/niosh-science-blog/2015/02/05/ebola-ppe/

Fire Fighter Fatality Investigation and Prevention Program, http://www.cdc.gov/niosh/fire/default.html

Fire Fighter Fatality Investigation and Prevention, http://www.cdc.gov/niosh/fire

Flavorings-related Lung Disease, http://www.cdc.gov/niosh/topics/flavorings

Flavorings-related Lung Disease, http://www.cdc.gov/niosh/topics/flavorings/processing.html

Genetics in the Workplace: Implications for Occupational Safety and Health, https://www.cdc.gov/niosh/docs/2010-101/pdfs/2010-101.pdf

GeoLibrary, http://www.geolibrary.org/

Homicide Prevention: How Many Drivers are Killed Each Year?, http://www.taxi-library.org/safety.htm

Horrible Bosses: Workplace Violence in the Real World, http://blogs.cdc.gov/niosh-science-blog/2011/07/18/violence/

Hospital Respiratory Protection Toolkit, http://www.cdc.gov/niosh/docs/2015-117/pdfs/2015-117.pdf

Implementing Hospital Respiratory Protection Programs: Strategies from the Field, http://www.jointcommission.org/implementing_hospital_respiratory_protection_programs_strategies_from_the_field/

Improved Safety for Truck Drivers: Designing Safer Cabs Based on Driver Body Dimensions, http://www.cdc.gov/niosh/docs/2011-188/

Improving Patient and Worker Safety: Opportunities for Synergy, Collaboration, and Innovation, http://www.jointcommission.org/improving_Patient_Worker_Safety/

Influenza, http://www.cdc.gov/niosh/topics/flu/activities.html

Intervening for Work Stress, http://blogs.cdc.gov/niosh-science-blog/2014/11/17/stress-webinar/

Isocyanates, http://www.cdc.gov/niosh/topics/isocyanates/

Ladder Safety, http://www.cdc.gov/niosh/topics/falls/mobileapp.html

Making the Case for Paid Sick Leave, http://blogs.cdc.gov/niosh-science-blog/2012/07/30/sick-leave/

Measuring How Well Earplugs Work, http://www.cdc.gov/niosh/docs/2015-181/

Methylene Chloride Hazards for Bathtub Refinishers, http://www.cdc.gov/niosh/docs/2013-110/pdfs/2013-110.pdf

Mining Topic: Emergency Communications and Tracking, http://www.cdc.gov/niosh/mining/topics/EmergencyCommunicationsandTracking.html

Nail Gun Safety Publications, http://www.cdc.gov/niosh/topics/nailgun/default.html

Nail Gun Safety: A Guide for Construction Contractors, http://www.cdc.gov/niosh/docs/2011-202/

Nanomaterial Production and Downstream Handling Processes, http://www.cdc.gov/niosh/docs/2014-102/pdfs/2014-102.pdf

Nanotechnology at NIOSH, http://www.cdc.gov/niosh/topics/nanotech/nanotechnology-research-center.html

National Birth Defects NIOSH Publications, http://www2a.cdc.gov/nioshtic-2/BuildQyr.asp?s1=National+Birth+Defects+Prevention+Study

National Safety Stand-Down, http://www.osha.gov/StopFallsStandDown

New LEED Pilot Credit: Prevention through Design, http://www.usgbc.org/articles/new-leed-pilot-credit-prevention-through-design

NIOSH and the Mid-Air Collision Avoidance Working Group Prevent Aircraft Collisions in Alaska, http://www.cdc.gov/niosh/docs/2015-120/default.html

NIOSH Center for Direct Reading and Sensor Technologies, https://www.cdc.gov/niosh/docs/2016-132/

NIOSH Hazard Review: Carbonless Copy Paper, http://www.cdc.gov/niosh/docs/2001-107/

NIOSH Hazard Review: Health Effects of Occupational Exposure to Respirable Crystalline Silica, http://www.cdc.gov/niosh/docs/2002-129/

NIOSH Hazardous Drugs List, http://www.cdc.gov/niosh/docs/2014-138/pdfs/2014-138.pdf

NIOSH Manual of Analytical Methods (NMAM), https://www.cdc.gov/niosh/docs/2003-154/

NIOSH Pesticide Poisoning Monitoring Program Protects Farmworkers, http://www.cdc.gov/niosh/docs/2012-108/

NIOSH Program Portfolio, http://www.cdc.gov/niosh/programs/

NIOSH Research on Work Schedules and Work-related Sleep Loss, http://blogs.cdc.gov/niosh-science-blog/2012/03/09/sleep/

NIOSH Survey, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4504242/

NIOSH Training for Nurses on Shift Work and Long Work Hours, http://www.cdc.gov/niosh/topics/workschedules/default.html

NIOSH-Designed Technology Can Reduce Workers' Exposure to Silica at Hydraulic Fracturing Sites, http://www.cdc.gov/niosh/updates/upd-11-04-15.html

NIOSHTIC-2, https://www2a.cdc.gov/nioshtic-2/default.asp

Occupational Cancer, http://www.cdc.gov/niosh/topics/cancer/

Occupational Exposures to Styrene Vapor in a Manufacturing Plant for Fiber-Reinforced Composite Wind Turbine Blades, http://dx.doi.org/10.1093/annhyg/mer021

Occupational Health Disparities, http://onlinelibrary.wiley.com/doi/10.1002/ajim.v53:2/issuetoc

Occupational Violence, http://www.cdc.gov/niosh/topics/violence/training_nurses.html

Online Training Helps Protect Nurses and Other Healthcare Workers From Workplace Violence, http://www.cdc.gov/niosh/docs/2015-118/

Part G of the Ryan White Act, http://www.cdc.gov/niosh/topics/ryanwhite/

Personal Protective Technology, http://www.cdc.gov/niosh/programs/ppt/projects.html

Police and Stress, http://blogs.cdc.gov/niosh-science-blog/2008/06/30/police/

PPT Conformity Assessment, http://www.cdc.gov/niosh/docket/archive/docket237.html

Productive Aging and Work, http://www.cdc.gov/niosh/topics/productiveaging/ncpaw.html

Protecting Healthcare Workers: Preventing Needle Stick Injuries Toolkit, http://www.who.int/occupational_health/activities/pnitoolkit/en

Quality of WorkLife Questionnaire, http://www.cdc.gov/niosh/topics/stress/qwlquest.html

Reducing Hazardous Dust Exposure When Cutting Fiber-Cement Siding, http://www.cdc.gov/niosh/docs/wp-solutions/2015-185/pdfs/2015-185.pdf Reducing Taxicab Homicides, http://blogs.cdc.gov/niosh-science-blog/2013/07/08/taxicab-homicides/

Report on the State of the Science and Directions for Future Research in Cleaning and Disinfecting Agents, http://www.ajicjournal.org/article/S0196-6553(15)00075-9/fulltext

Research Agenda for the Nation, http://www.cdc.gov/niosh/nora/comment/agendas/hlthcaresocassist/pdfs/HlthcareSocAssist-Feb2013.pdf

Safe Patient Handling and Mobility: Interprofessional National Standards, http://nursingworld.org/DocumentVault/OccupationalEnvironment/SPHM-Standards-Resources/Sample-of-the-SPHM-book.pdf

Safe-Skilled-Ready Workforce Program, http://www.cdc.gov/niosh/docs/2016-147/pdfs/2016-147.pdf

Safety-related Website, https://polyurethane.americanchemistry.com/Spray-Truck-Bed-Liner/Truck-Bed-Liner-Video.html

Skin Exposures and Effects, http://www.cdc.gov/niosh/topics/skin/skin-notation_profiles.html

Sleep and Work, http://blogs.cdc.gov/niosh-science-blog/2012/03/08/sleep-and-work/

Small Business, http://www.cdc.gov/niosh/topics/smbus/

Spray Truck Bed Liner: Health, http://polyurethane.americanchemistry.com/Spray-Truck-Bed-Liner/Health.html

State-of-the-Sector Report, http://www.cdc.gov/niosh/docs/2009-139/pdfs/2009-139.pdf

Stop Construction Falls: Safety Pays, Falls Cost, http://www.stopconstructionfalls.com/

Straight Talk About Nail Gun Safety, http://www.cdc.gov/niosh/docs/2013-149/

Stress and Health in Law Enforcement, http://blogs.cdc.gov/niosh-science-blog/2012/08/13/policestress/

Stress at Work, http://www.cdc.gov/niosh/topics/stress

Survey of Occupational Injuries and Illnesses, http://www.bls.gov/iif/

The Sector and Cross-Sector Approach, http://www.cdc.gov/niosh/nora/sector.html

Total Worker Health® Twitter Chat on Stress, https://twitter.com/niosh_twh

TWH™ in Action!, http://www.cdc.gov/niosh/TWH/newsletter/TWHnewsv2n3.html

U.S. News Twitter Chat on Sleep Health, http://health.usnews.com/health-news/health-wellness/articles/2013/08/28/us-news-twitter-chat-on-sleep-health

Violence Against Nurses Training, http://www.cdc.gov/niosh/topics/violence/training_nurses.html

Violence in the Workplace, http://gss.norc.org/Website, https://www.cdc.gov/niosh/topics/noise/pubs.html

What Works Best to Prevent Stress Among Healthcare Workers: Changing the Organization or Educating Staff?, http://blogs.cdc.gov/niosh-science-blog/2014/12/11/hc-stress/

Wholesale and Retail Trade, http://www.cdc.gov/niosh/programs/wrt/pubs.html/

Women's Health at Work, http://blogs.cdc.gov/niosh-science-blog/2013/05/13/womens-health-at-work/

Work Organization Measures Inventory, http://www.cdc.gov/niosh/programs/workorg/other.html

Work, Stress, and Health 2017: Contemporary Challenges and Opportunities, http://www.apa.org/wsh

Work, Stress, and Health: Help Us Plan the Next 25 Years, http://blogs.cdc.gov/niosh-science-blog/2015/07/01/workplace-stress/

Worker Exposure to Crystalline Silica During Hydraulic Fracturing, http://blogs.cdc.gov/niosh-science-blog/2012/05/23/silica-fracking/

Worker Exposure to Silica During Hydraulic Fracturing, https://www.osha.gov/dts/hazardalerts/hydraulic_frac_hazard_alert.pdf

Workplace Safety and Women Podcast, https://www2c.cdc.gov/podcasts/player.asp?f=11503

Workplace Stress, http://blogs.cdc.gov/niosh-science-blog/2007/12/03/stress/

Workplace Violence Prevention for Nurses, http://www.cdc.gov/niosh/topics/violence/training_nurses.html

Young Retail Workers, http://www.cdc.gov/niosh/topics/retail/default.html?s_cid=3ni7d2twSCIBLOGyrwtopic20156062016

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